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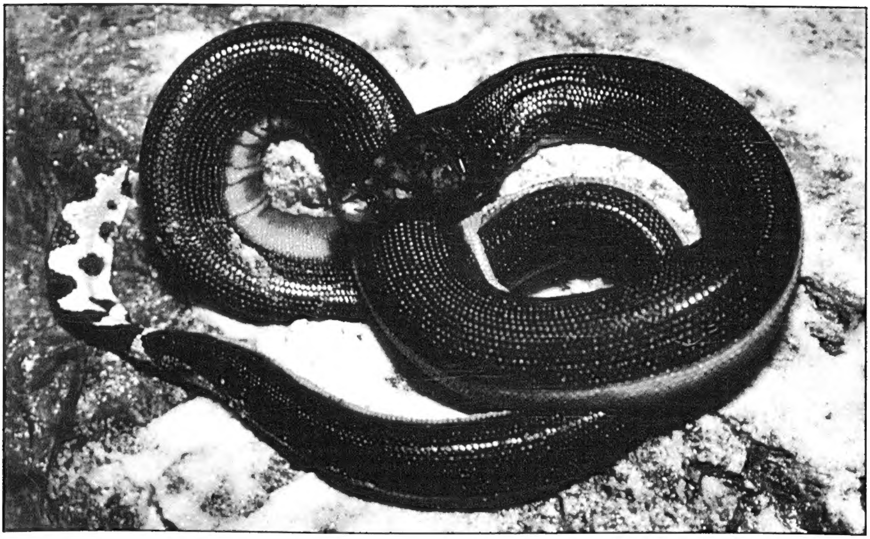
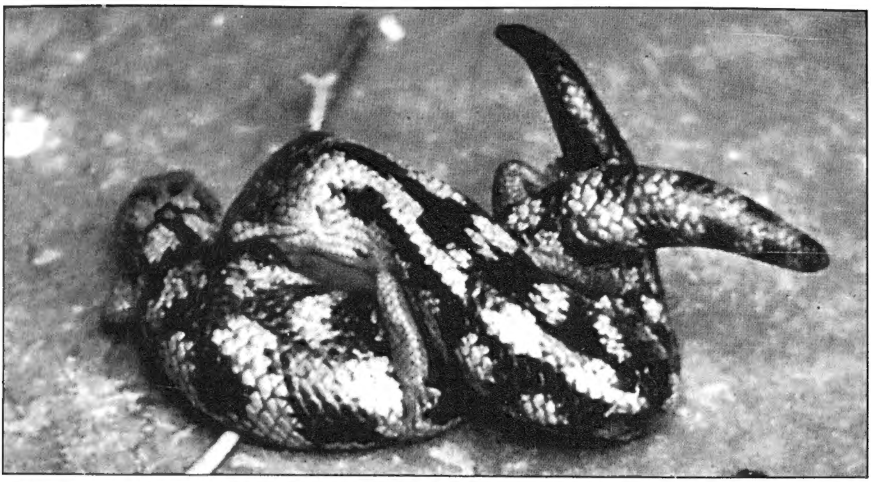


Yellow-bellied Sea Snake (*Pelamis platurus*) from Bondi, NSW.. See paper on page 110.
(Photo by G.Shea).



Mating Blotched Blue-Tongue Lizards (*Tiliqua nigrolutea*). See paper on page 60.
(Photo by A. Edwards).

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OBSERVATIONS OF DIURNAL EXPOSURE BY GECKOS

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ABSTRACT

This note reports apparent diurnal exposure to sunlight in two species of gecko, the Thick-tailed Gecko *Underwoodisaurus milii* and the Southern Spiny-tailed Gecko *Strophurus intermedius*, from the Wagga Wagga district, NSW.

INTRODUCTION

Australian geckos are generally regarded as nocturnal lizards (Cogger, 2000). Observations of diurnal activity in Australian geckos are few. Ehmann (1980) reported three observations of Southern Spiny-tailed Geckos (*Strophurus intermedius*) perching on thin twigs exposed to sunlight, and Wilson and Knowles (1988) reported that some geckos (particularly members of the *Strophurus ciliaris* species group) may bask and forage in weak sunlight.

This note provides an additional observation of diurnal perching by *S. intermedius*, observations of a Thick-tailed Gecko (*Underwoodisaurus milii*) in the wild out by day, and of captives of the same species emerging from shelter during the day to feed.

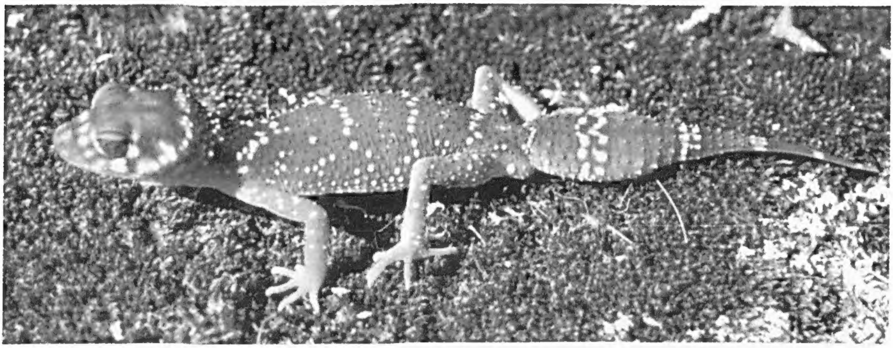
OBSERVATIONS

On 18 March 2002, one *S. intermedius* (Figure 1) was observed at 0930 hrs perched 125 cm above the ground on the horizontal bare branches of an *Acacia* at Bald Hill (35°03'40"S 147°21'10"E, 306 m a.s.l.). The adult female gecko measured 74 mm snout-vent length (SVL) and showed no visual signs of stress, nor appeared gravid. Weather conditions on the day were partly cloudy with air temperature recorded at 17.3°C. This lizard was in full sunlight at the time of observation.

On 11 September 2002 at Mt Kiaora (35°06'20"S 147°32'30"E, 351 m a.s.l.), a *U. milii* measuring 92 mm SVL (Figure 2) was observed at 1005 hrs at ground level on an exfoliated granite outcrop with a westerly aspect. Although there was a clear sky, the

Figure 1. Diurnal perching by *Strophurus intermedius*. Photograph by Chris Coombes.

Figure 2. *Underwoodisaurus milii* exposed on a granite outcrop by day. Photograph by Chris Coombes.



gecko was not in full sun. Air temperature was estimated to be 13°C.

Captive *U. milii* in my care regularly emerge from shelter sites during daylight hours to hunt for food. Ample food is provided during night periods in the form of crickets, with three to four adult-sized insects offered per gecko at each feeding. However, when further food is offered during daylight hours, most individuals emerge to forage. Food not consumed within a few minutes is usually removed. The geckos are also active within their enclosure when food is not available. All specimens are captive-bred.

DISCUSSION

Whether these two species and other species of geckos are diurnally active in the field on a regular basis is not known. However, the paucity of similar observations for these two species suggests that it is uncommon.

Both field observations were of stationary animals that showed little activity, and it is probable that the diurnal exposure was basking behaviour.

However, both field observations were made during extended periods without rainfall. In the case of the *U. milii*, it had been 10 months since substantial rain had fallen. It is possible that this low rainfall led to a reduction in insect activity, necessitating extended foraging activity by the gecko, either into the day itself or late into the night, followed immediately by diurnal basking to aid digestion. Similar diurnal basking after feeding is commonly observed in nocturnal Carpet and Diamond Pythons (*Morelia spilota*).

The diurnal feeding observed in captive *U. milii* may be indicative of such opportunistic feeding by day in the wild, or might simply be a captive change in behavioural pattern in individuals having no exposure to predators.

ACKNOWLEDGMENTS

Many thanks to Glenn Shea and Skye Wassens for reviewing this manuscript. Thank you to Chris Coombes for his assistance in the field and his photographic abilities. My research is carried out under NSW National Parks and Wildlife Service Scientific License A3086.

REFERENCES

Cogger, H.G. 2000. Reptiles and Amphibians of Australia. Reed New Holland, Sydney.

Ehmann, H. 1980. Diurnal perching by the Southern Spiny-tailed Gecko, *Diplodactylus intermedius*. Herpetofauna 12(1): 37.

Wilson, S.K. & Knowles, D.G. 1988. Australia's Reptiles. A Photographic Reference to the Terrestrial Reptiles of Australia. William Collins, Sydney.

MATING BEHAVIOUR IN THE BLOTCHED BLUE-TONGUED LIZARD, *TILIQUA NIGROLUTEA*, IN CAPTIVITY

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INTRODUCTION

Southern or blotched blue-tongued lizards, *Tiliqua nigrolutea*, are large, viviparous skinks distributed throughout southeastern Australia (Cogger, 1992). Adult males can range from 25–29 cm snout–vent length (SVL) and weigh between 300 and 450 g, with females somewhat larger and heavier. In Tasmania, where this study was conducted, blue-tongued lizards occur in low altitude heath, savanna woodland and dry sclerophyll forest in the cool temperate regions of the state (Rawlinson, 1974). We studied the reproductive biology of blue-tongued lizards for five years during a PhD project examining the roles of steroid hormones in reproductive physiology and behaviour, and here we describe our observations of mating behaviours in blue-tongued lizards in captivity.

METHODS

We caught lizards by hand throughout southeastern Tasmania: males were distinguished from females by their relatively broader heads and an examination of the cloacal opening for the musculature of the hemipenes. During our study, the animals were housed in roofed outdoor enclosures 1.9 x 3.4 x 2.1 m; these were wire-fronted, allowing access to UV light and a natural photoperiod, and we provided bark and leaf litter for the animals to hide in. Direct sunlight and a 120 W floodlight globe at the front of each cage as an additional heat source provided a temperature gradient across which the lizards could thermoregulate during their active season of spring (Sept) to mid-autumn (Apr).

The lizards were maintained on a varied diet of fresh fruits (banana, apple, pear, grapes), snails and tinned, meat variety catfood, provided two to three times weekly. Water was available at all times. Mixed-sex groups of approximately five animals were maintained in each cage from early autumn (Mar) to early spring (Sept); during this period animals were not breeding and few interactions were observed between individuals. However, during the mating period (mid to late spring: Oct – Nov), we separated males from each other in similar, but smaller, cages because males can injure each other during fights. The males were then rotated between cages of females until the end of the mating season.

OBSERVATIONS AND DISCUSSION

We observed animals once every hour each day during the mating period, and continuously until the day's end once we saw the first sign of interest of a male in a female. We first observed reproductive behaviours in our lizards in mid–spring (Oct), and we witnessed copulations on at least seven occasions during the mating period. We encountered and captured males in the wild much more regularly at this time of year, and found many killed by the roadside (probably as they searched for females), but we rarely encountered females (active or inactive) in the wild in spring. Approximately 95% of the total opportunistic encounters with or captures of blue-tongued lizards (N = 18) we examined in the month of October from 1995-1998 reproductive seasons were males. A similar trend has been observed in the related species *T. rugosa* in South Australia, in which in most cases, it was the male lizard which actively located the female for mating by following her scent trail, tongue-flicking at airborne signals or searching familiar sites (Bull *et al.*, 1993).

Male blotched bluetongues would test the receptivity of a female repeatedly early in the

mating period. A mating attempt by a male began with an approach to the female from the side or rear, walking with jerky, irregular movements with his body raised above the ground and at the same time flicking his tongue toward her head, lateral body and cloaca (Figure 1). The male then initiated a chase around the cage, attempting to grasp the resisting female, using his mouth, on the lateral torso, immediately posterior to the front legs (Figure 2). It often took several attempts for a male to secure a grip, as the female ran away or struggled violently. Once in position, the male curled his body around the female's, positioning his cloaca alongside hers. The male then tilted the whole body of the female (which was rigid) forcibly, until her cloaca became exposed. At this point, the female

Figure 1. The male (below) approaches the female and tongue-flicks her head, side and cloaca.

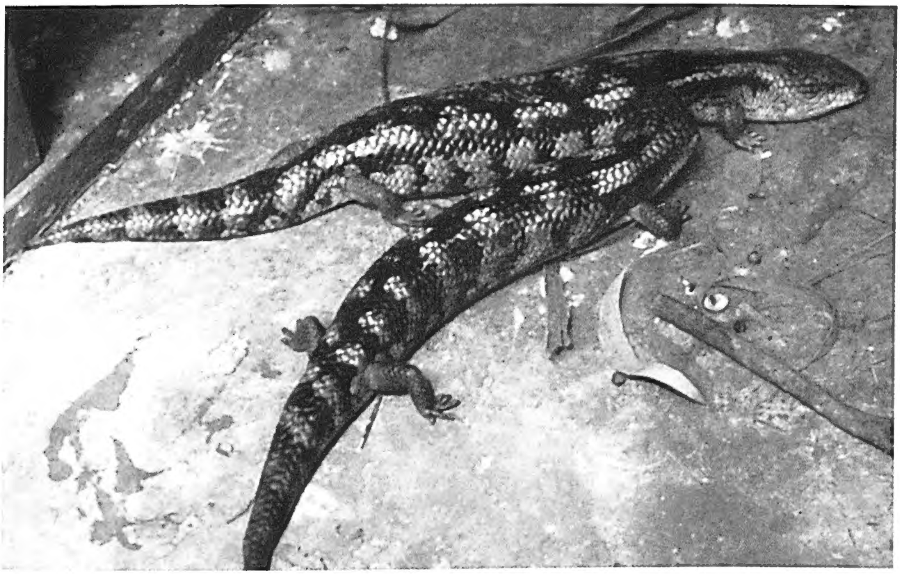
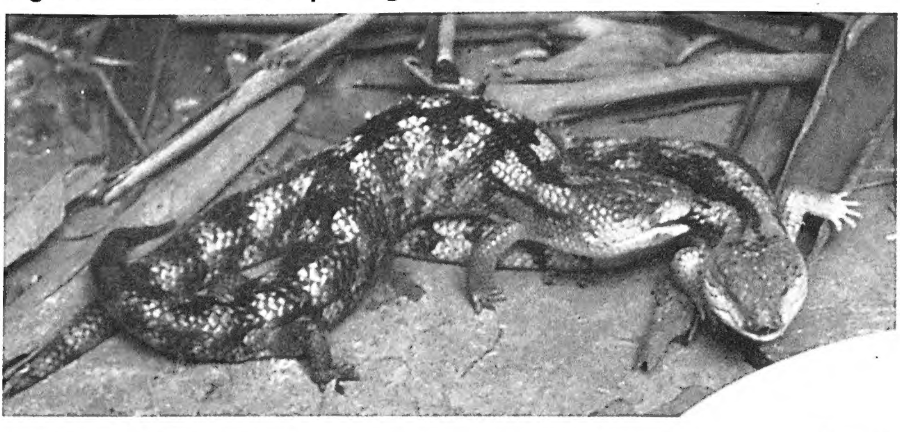


Figure 2. The male attempts to gain a secure bite hold on the female.

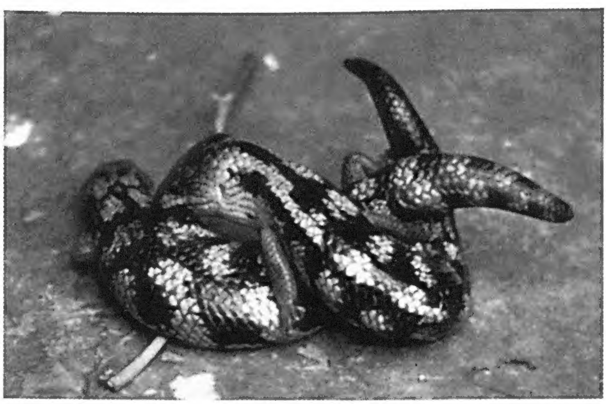


occasionally broke free and ran, only to be chased and recaptured by the male. The male then used one of his hind feet to scratch the female dorsally at the base of the tail several times (Figure 3). A receptive female responded by raising her tail and gaping her cloaca and allowing the male to intromit a hemipenis (Figure 4). If the female was unreceptive, she simply did not present her cloacal opening, and eventually the male released her.

The duration of copulation was highly variable; one male was observed to maintain his grasp on a female for approximately six hours, with intromission only occurring towards the end of that time. A mating involving two other lizards lasted only about 30 min. More usually, the chase and actual copulation were relatively rapid, with the male then maintaining a post-mating grip on the female for at least one hour (Figure 5), preventing her from leaving despite her attempts to do so. This may be a form of mate-guarding. However, males showed no loyalty to any particular female. Most attempted, often repeatedly, to copulate with two or more different females during the mating period, sometimes on the same day. Females became unreceptive

Figure 3. The male (above) uses his hind leg to scratch the female (below) on the base of the tail, to stimulate her to gape her cloacal opening if she is receptive to mating.

Figure 4. Intromission between male (right) and female (left).



immediately following intromission and responded to additional copulatory attempts by lunging and biting, hissing and gaping at the approaching male (Figure 6). However, one male was observed to successfully copulate twice with the same female: this occurred without the animals separating after the first intromission. No copulatory plugs were

Figure 5. The male (behind) maintains a post-mating grip on the female (in front).

Figure 6. The female (right) becomes unreceptive as soon as she is released by the male (left) after copulation.

observed, but the abdomen of mated females underwent several rhythmic contractions from posterior to anterior immediately after copulation, before the male's bite hold was released. This may be associated with ovulation, or to help the sperm move into the reproductive tract.

We observed several matings in which intromission was successful, but from which females did not conceive. We cannot be certain if these represent failures of insemination or of ovulation. Although males become reproductively active every year (Edwards & Jones, 2001a), females generally breed only every 2-3 years (Edwards *et al.*, 2002). It is possible that in a captive group situation males may be unable to discern whether or not an individual female has vitellogenic follicles: the proximity of a receptive female may confuse mating males. However females identified by hormone analysis as being non-vitellogenic were not receptive and did not mate, although males did still chase them.

The jerky, irregular walk observed as a male approached a female to attempt copulation has been described previously in this species as part of the limited courtship ritual of this species (Clutterbuck, pers. comm, cited in Shea, 1992). However, we observed this type of movement in several additional contexts, including male – male interactions, during both the mating period (Oct – Nov) and the less frequent male – male encounters in summer (Dec – Feb) when males were reproductively quiescent. During the mating period, however, the jerky walk signalled the interest of a male in a female, and usually preceded a chase. This behaviour is similar to that documented for male *Lacerta vivipara*, a lizard in which there is little preliminary activity before mating (Bauwens *et al.*, 1989).

As mentioned, two of the observed matings did not result in successful pregnancies, but the other five copulations produced healthy clutches. We have already published information about gestation length (Edwards & Jones 2001b), clutch number, reproductive frequency and relative clutch mass (Edwards *et al.*, 2002) in blotched blue-tongued lizards.

ACKNOWLEDGMENTS

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REFERENCES

Bauwens, D., Van Damme, R. & Verheyen, R.F.. 1989. Synchronization of spring molting with the onset of mating behaviour in male lizards. *Lacerta vivipara*. Journal of Herpetology 23(1): 89-91.

Bull, C.M., Bedford, G.S. & Schulz, B.A. 1993. How do sleepy lizards find each other? Herpetologica 49(3): 294-300.

Cogger, H.G. 1992. Reptiles and Amphibians of Australia. Reed Books, Australia.

Edwards, A., Jones, S.M. & Wapstra, E. 2002. Multiennial reproduction in females of a viviparous skink, *Tiliqua nigrolutea*. Herpetologica 58(4): 407-414.

Edwards, A. & Jones, S.M. 2001a. Changes in plasma testosterone, estrogen and progesterone concentrations throughout the annual reproductive cycle in male viviparous blue-tongued skinks, *Tiliqua nigrolutea*, (Scincidae), in Tasmania. Journal of Herpetology 35(2): 293-299.

Edwards, A. & Jones, S.M. 2001b. Changes in plasma progesterone, estrogen and testosterone concentrations throughout the annual reproductive cycle in female viviparous blue-tongued skinks, *Tiliqua nigrolutea*, (Scincidae), in Tasmania. General and Comparative Endocrinology 122: 260-269.

Rawlinson, P.A. 1974. Biogeography and ecology of the reptiles of Tasmania and the Bass Strait area. Pp. 230-269 in, Williams, W.D. (ed.). Biogeography and Ecology in Tasmania.W. Junk, The Hague.

Shea, G.M. 1992. The systematics and reproduction of blue-tongued lizards of the genus *Tiliqua* (Squamata: Scincidae). Ph.D. Thesis, University of Sydney, NSW, Australia

HERPETOFAUNA OF BOODJAMULLA NATIONAL PARK AND THE RIVERSLEIGH WORLD HERITAGE AREA, NORTH-WESTERN QUEENSLAND

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INTRODUCTION

Boodjamulla (Lawn Hill) National Park (282,000 ha) and the Riversleigh World Heritage Area (also known as Miyumba National Park; 10,000 ha) combined make up one of the largest areas of national park in Queensland. Despite the large size of the parks and the declaration of the Riversleigh Fossil Area as a World Heritage Site in 1994, the fauna of the area has only been lightly surveyed. O'Keefe (1996) listed some of the vertebrate fauna for the Lawn Hill section of Boodjamulla National Park while Horner (1998) noted the herpetofauna of the Musselbrook Reserve (prior to its incorporation into the national park). Other surveys have noted new species (e.g. McKay and Clarke, 1999). The unevenness of fauna data is a consequence of the inaccessibility of many parts of the national parks, the large distance from a capital city and the difficulty of terrain.

Systematic fauna surveys were commenced in the area in 1998 at the behest of the Riversleigh Fossil Project. This project has catalogued over 50,000 fossil specimens from the Riversleigh Fossil Area; this information has led to a reasonable understanding of the fossil local faunas from late Oligocene, Miocene, Pliocene and Pleistocene sites (Archer *et al.*, 1991). The scientific attention given to the fossil faunas has outstripped the knowledge of the extant fauna of the region. This was exemplified by the discovery of one of the largest species of freshwater turtle (known as the Gulf Snapping Turtle *Elseya lavarackorum*) in Australia in the nearby Gregory River and Lawn Hill Creek in 1995 (Thomson *et al.*, 1997); this species had previously been described from late Pleistocene fossil material from Riversleigh (White and Archer, 1994) but extant animals were unknown.

From 1986 to 1998, fauna records for this area were collected on an opportunistic basis by the author, but from 1998 onwards systematic surveys were conducted for mammals, reptiles and frogs; birds were not targeted as this was one of the few groups of vertebrate animals that had been thoroughly surveyed in the area. This paper will report on the results of the reptile and frog surveys only.

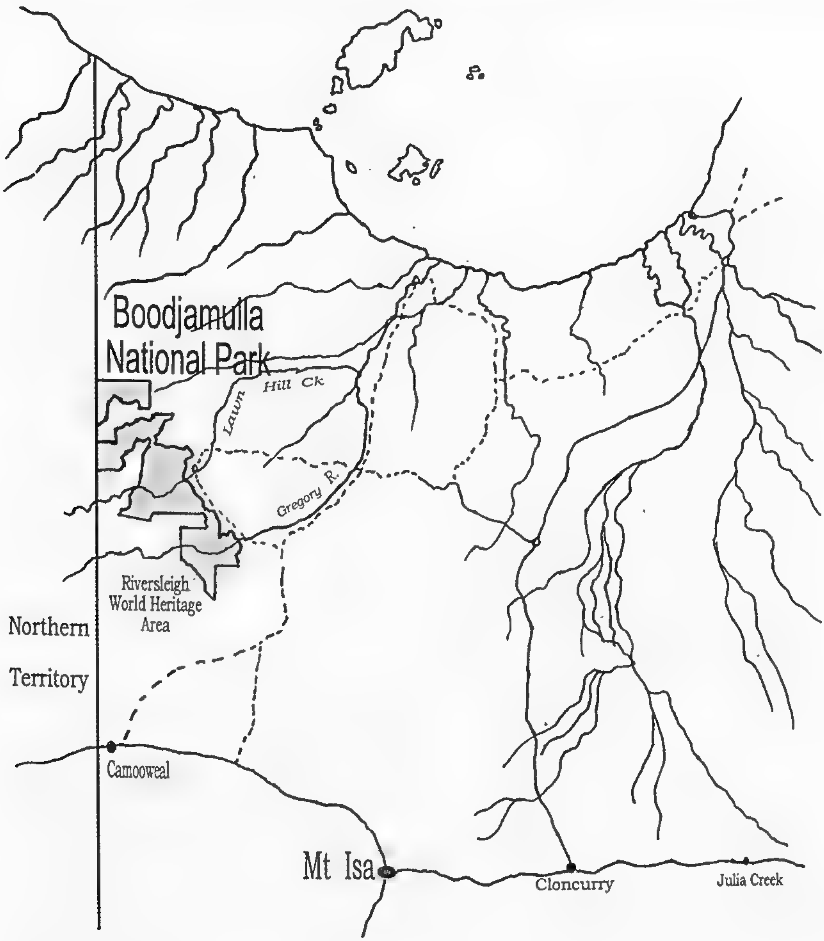
Apart from trying to reconcile the imbalance in knowledge between the fossil and extant faunas of the area, surveys were initiated as this region was also an area where further undescribed species were likely to be present, where new populations of already described species were likely to occur and where species assemblages were likely to be unique.

SURVEY AREA

Boodjamulla National Park and the Riversleigh World Heritage Area are located in the extreme north-west of Queensland and abut the border with the Northern Territory (Figure 1). This area forms part of the southern catchment area for several rivers leading into the Gulf of Carpentaria, notably the Nicholson, Gregory and O'Shannassy Rivers and Lawn Hill Creek.

Geologically, the area consists of an uplifted section of ancient sea floor. The most conspicuous base rock throughout the area is a horizontally-bedded marine limestone (Thorntonia Limestone: see Archer *et al.*, 1989). This limestone is Cambrian in age and is impregnated with irregular chert nodules. To the north, in Boodjamulla National Park, this base rock is overlain by an iron-rich marine sandstone (Constance Series); to the south in the Riversleigh World Heritage Area, it is overlain by Cainozoic limestones and black soils. In Boodjamulla National Park, the sandstone has

Figure 1. Riversleigh World Heritage Area and Boodjamulla National Park.



been deeply eroded to create gorges and steep escarpments across a deeply dissected plateau; in the Riversleigh World Heritage Area, the Cambrian and Cainozoic limestones have also been deeply weathered to create deep fissures, sink holes, fluted ridges and limestone boulders.

The area lies within the monsoon-affected north of Australia: 90% of all rain falls within the summer months. The average annual rainfall is about 500 mm but this can vary from 3,700 mm to 187 mm in a year (Bureau of Meteorology). This great variability in rainfall, combined with the rapid run-off and short duration of flooding, has resulted in extensive erosion of surface rocks and the establishment of dry savanna vegetation away from the rivers.

The vegetation assemblages in the area generally fall into four broad types (Bean, 1991):

Figure 2. Gallery rainforest along the Gregory River

1. Gallery Rainforest (Figure 2); narrow bands of rainforest dominated by tall Paperbarks *Melaleuca leucadendra*, Leichardt's Tree *Nauclea orientalis*, Cabbage Palm *Livistona mariae* and Screw-Pine *Panadanus aquaticus*. The gallery rainforest often exists as a green strip on either bank of the larger rivers and creeks in the area.

2. Plains Open Woodland: away from the rivers, the rainforest quickly gives way to open woodland growing on the alluvial clay plains. The main trees present are Western Bloodwoods *Eucalyptus terminalis*, Cabbage Gum *E. cornutifolia*, Silver-leafed Box *E. grandifolia*, Snappy Gum *E. brevifolia* and various species of low acacias. The ground cover is typically comprised of spinifex and other native grasses.

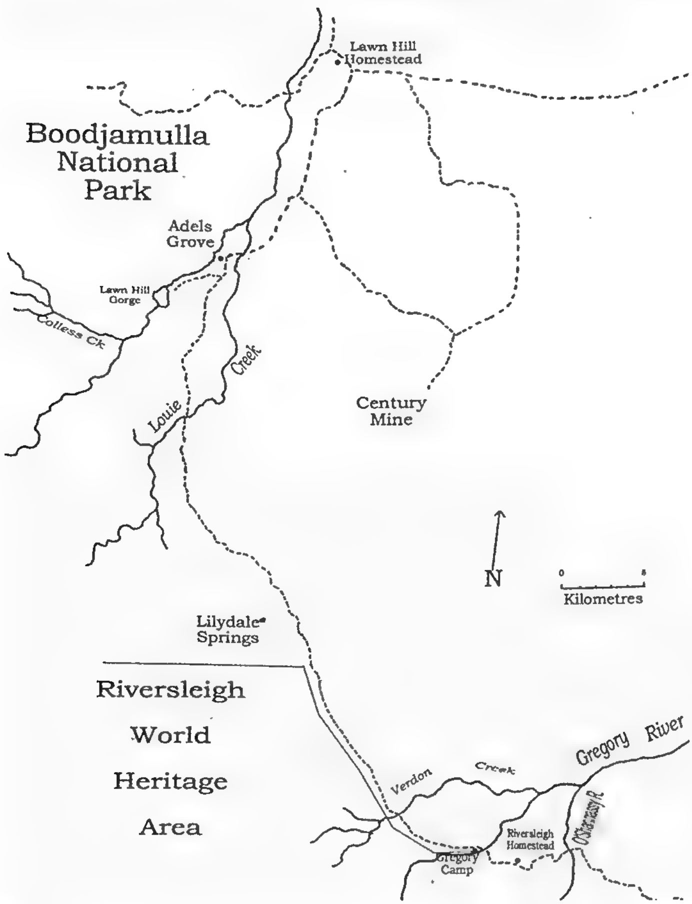
Figure 3. Limestone Woodland, Riversleigh World Heritage Area

3. Limestone Woodland (Figure 3): this sparse woodland consists of a heterogeneous mixture of trees that are able to tap the sparse water reserves in the limestone plateaux. Stunted *Alphitonia* and *Acacia* are present on the more exposed areas of limestone whereas Kurrajongs *Brachychiton collinus* and Figs *Ficus platynoda* and *F. coronata* grow in deep fissures and sink holes. Clumps of spinifex *Triodia pungens* and *T. longiceps* grow wherever there is enough soil to support them.

4. Sandstone Woodland: sparse woodland dominated by Brittle Bloodwood *Eucalyptus aspersa*, Snappy Gum *E. brevifolia*, *Terminaria aridicola* and Emu Apple *Owenia acidula*. Unlike the limestone woodland, the understorey of sandstone woodland is dense and diverse and contains a variety of tall shrubs, mostly species of *Grevillea, Acacia and Calytrix*.

There are relatively few vehicle tracks in the national parks; survey sites tended to be located within one kilometre of tracks. In general, the survey area was confined to only the eastern portion of the two national parks (Figure 4) and was bounded by Adels Grove to the north, Colless Creek to the west, the O'Shannassy River to the south and the Gregory River to the east.

Figure 4. Limits of survey area at Riversleigh and Lawn Hill



METHODS

Pre 1998

Occasional fauna records were kept by the author for the Riversleigh Fossil Area since 1986. From 1986 to 1998, reptiles and frogs that were chanced upon were captured, identified if possible and released. Details of location, body length, sex, scale counts, body markings and other diagnostic features were recorded by the author in a separate database.

Occasional fauna records were also kept by the staff of the Queensland National Parks and Wildlife Service based at Lawn Hill. In particular, Ranger Colin O'Keefe maintained a detailed register of animal sightings from December 1985 through to March 1996 for the area around Lawn Hill Gorge and Adels Grove.

1998-2002

Various survey methods were employed to try to detect the whole range of reptile and frogs species in the area. Systematic surveys included various trapping methods such as the use of metal pit traps and drift fences in areas where the ground was soft enough to employ pits, the use of large amounts of slippery plastic sheeting in hollows in limestone or sandstone as a type of pit trap, submerged and baited barrel traps for turtles and setting out lengths of corrugated iron or timber as shelter boards for dispersing animals to refuge under. Traps and boards were checked every morning before 9.00 am and animals inside were transferred to a labelled holding bag. After all the traps had been cleared, the animals were removed from the bags, identified and later returned to the site of capture. Frogs were retained in damp holding bags until the next night and then released at the site of capture.

In addition, non-trapping methods were used. On warm nights, vehicle tracks were driven slowly and reptiles and frogs detected by spotlight from the car were caught, identified and released. Hand searches were carried out in rocky areas where rock slabs could be upturned and sheltering reptiles and frogs collected. At night, spotlight searches were carried out along the rivers and creeks and around waterholes in search of frogs and tadpoles and in woodland and rocky escarpments for nocturnal reptiles. During the day, snorkelling searches were carried out in the larger rivers and creeks for turtles and aquatic snakes.(see White, 1999).

The surveys enlisted the assistance of a number of volunteers, especially Earthwatch volunteers. Volunteers were recruited from the Riversleigh Fossil Project on a daily basis although some worked mostly on the fauna survey.

Survey Times

As the surveys were part of the Riversleigh Fossil Project, all surveys were carried out when the fossil team was on site. This invariably meant that surveys were carried out in either June or July of each year and so the survey results will be skewed towards dry season species. The dates for the surveys are presented in Table 1.

Table 1. Survey Dates

Year	Survey Duration
1998	12 June – 17 July
1999	28 May – 10 June
2000	14-29 June
2001	14-30 June
2002	18-28 June

Species Identification

Reptiles and frogs were identified using Cogger (2000). Difficult taxa were photographed and measurements and scale counts taken. Corroboration of identifications were made by Dr Allen Greer (Australian Museum) and Dr Glenn Shea (University of Sydney). Further amendments to scientific names used are based on the advice of Dr Andrew Amey (Queensland Museum) and Dr Glenn Shea.

Incidental records

Apart from the systematic survey, reports of sightings of fauna were made to us by members of the public visiting the national parks, by interested land holders and by tourist operators. In each case, the sighting was not included in the database unless it could be confirmed by an acknowledged herpetologist.

The main areas surveyed each year are summarised in Table 2.

Impact of Cane Toads

In order to determine the initial impact of the arrival of cane toads on the local herpetofauna, comparisons were made of the herpetofauna diversity before and after the arrival of the toads. Cane toads reached Lawn Hill Creek in 1986, before any systematic surveys had been carried out in the area; cane toads reached the Gregory Camp (Figure 4) in late 1987 but were still in low numbers in June 1988. Since then they have been abundant and widespread throughout the survey area.

A comparison of reptile and frog species recorded before and after the arrival of cane toads at Riversleigh camp was made. As cane toads arrived within a year of the commencement of surveys in most areas it was not possible to compare changes in species abundance, it was possible however to detect any changes in species composition.

RESULTS

The full list of reptile species detected during the surveys is presented in Table 3, and frogs that were detected during the surveys are listed in Table 4.

DISCUSSION

Reptiles

A total of 77 reptile species was detected in the survey areas; these comprised 1 species of crocodile, 4 turtles, 16 geckos, 4 pygopodids, 6 dragons, 7 goannas, 17 skinks, 22 species of snakes (Table 3). This is a very high diversity and makes the area one of the most reptile rich in Australia (Cogger & Heatwole, 1981). The high diversity is undoubtedly related to the range of habitats available and the seasonal variability. The Limestone Woodland and Sandstone Woodland habitats contain a high density of shelter sites, ranging from loose rocks, to deep fissures and caves. The relatively large number of permanent rivers and creeks that traverse the area also means that water is freely available, even during the dry season. Water points are also scattered throughout the deeply eroded plateaux, permanent springs, pools and seepage areas are

Table 2. Summary of Survey Areas

Year	Boodjamulla National Park	Riversleigh World Heritage Area	Other
1998	Lawn Hill	Godthelps Hill, area south of D Site	Gregory River, Lawn Hill Creek
1999	Lawn Hill, Louie Creek area	D Site, Verdon Creek area, Gregory River area	Gregory River, Ixion Creek
2000	Lawn Hill area	Riversleigh mesas, AL 90	Gregory River
2001	Lawn Hill area	Gag Plateau, Bitesantenary Valley	Lawn Hill Creek, Louie Creek, Adels Grove
2002	Lawn Hill Caves, Colless Creek, Louie Creek area	Hals Hill, Burnt Offerings	Lawn Hill Creek, Louie Creek, Adels Grove

Table 3. List of Reptiles from Survey Areas

Common Name	Species	Areas	Habitat	Abundance
Crocodylidae				
Freshwater Crocodile	*Crocodylus johnstoni*	R,LH,AG,O	Aq	1
Chelidae				
Northern Snake-necked Turtle	*Chelodina canni*	R,O	Aq	3
Gulf Snapping Turtle	*Elseya lavarackorum*	R,LH,AG,O	Aq	1
Saw-shelled Turtle	*Elseya latisternum*	R	Aq	3
Worrell's Turtle	*Emydura worrelli*	R,LH,AG,O	Aq	1
Gekkonidae				
Clawless Gecko	*Crenadacylus ocellatus*	R	OPW	3
Burrow-plug Gecko	*Diplodactylus conspicillatus*	R,LH,O	LW,SW	1
Pale-snouted Gecko	*Diplodactylus stenodactylus*	R,LH,O	OPW,SW	2
Tessellated Gecko	*Diplodactylus tessellatus*	R	OPW	3
Top-end Dtella	*Gehyra australis*	R,LH	GRF	1
Robust Dtella	*Gehyra robusta*	LH	SW	2
Northern Spotted Rock Dtella	*Gehyra nana*	R,LH,O	SW, LW	1
Dtella sp. 1	*Gehyra sp. 1*	LH	SW	2
Dtella sp. 2	*Gehyra sp. 2*	R,LH	LW	1
Bynoe's Gecko	*Heteronotia binoei*	R,LH,AG,O	OPW, SW, LW	1
Cave Gecko	*Heteronotia sp. cf. spelea*	R,LH	C	1
Marbled Velvet Gecko	*Oedura marmorata*	R,LH,O	GRF	2
Zigzag Velvet Gecko	*Oedura rhombifer*	R	GRF	3
Northern Spiny-tailed Gecko	*Strophurus ciliaris*	R,LH,AG	OPW,SW	1
Phasmid Striped Gecko	*Strophurus taeniatus*	R	LW	3
Golden Striped Gecko	*Strophurus taenicauda*	LH	SW	3
Pygopodidae				
Rusty-topped Delma	*Delma borea*	R	LW	3
Excitable Delma	*Delma tincta*	R	LW	3
Burton's Legless Lizard	*Lialis burtonis*	R,LH	OPW,LW,SW	2
Hooded Scaly-foot	*Pygopus steelescotti*	R,LH	LW,SW	3
Agamidae				
Gilbert's Water Dragon	*Amphibolurus gilberti*	R,LH,AG,O	GRF,SW	1
Frilled Dragon	*Chlamydosaurus kingii*	R,LH	OPW,SW	3
Northern Two-lined Dragon	*Diporiphora bilineata*	R,LH	GRF,SW	2
Two-lined Earless Dragon	*Tympanocryptis lineata*	LH	SW	3
Ring-tailed Dragon	*Ctenophorus caudicinctus*	R,LH,O	OPW,SW	1
Chameleon Dragon	*Chelosania brunnea*	LH	LW	3
Varanidae				
Ocellated Ridge-tailed Monitor	*Varanus acanthurus*	R,LH,AG,O	OPW,SW	1
Black-palmed Rock Monitor	*Varanus glebopalma*	LH	GRF	3
Merten's Water Monitor	*Varanus mertensi*	R,LH,O	GRF	*
Mitchell's Water Monitor	*Varanus mitchelli*	LH	GRF	*
Yellow-spotted Monitor	*Varanus panoptes*	R,LH	GRF,LW	3
Spotted Tree Monitor	*Varanus scalaris*	LH	SW	3
Black-tailed Monitor	*Varanus tristis*	R,LH	GRF,LW	2
Scincidae				
Bauxite Rainbow Skink	*Carlia amax*	R,LH	LW, SW	1
Spiny-palmed Shinning Skink	*Cryptoblepharus carnabyi*	R,LH	GRF	2

Blotched Shinning Skink	*Cryptoblepharis megastictus*	R,LH	LW,GRF	3
Callous-palmed Shinning Skink	*Cryptoblepharus plagiocephalus*	LH	GRF	3
Ten-lined Ctenotus	*Ctenotus decaneurus*	LH	LW	3
Inornate Ctenotus.	*Ctenotus inornatus*	R,LH,O	SW,LW,OPW	1
Pulchellate Ctenotus	*Ctenotus pulchellus*	R	LW	3
Leonhardi's Ctenotus	*Ctenotus leonhardii*	R	LW	3
Side-striped Ctenotus	*Ctenotus lateralis*	R	LW	3
Narrow-banded Ctenotus	*Ctenotus hebetior*	R	GRF	1
Leopard Ctenotus	*Ctenotus pantherinus*	R,LH	GRF	2
Spalding's Ctenotus	*Ctenotus spaldingi*	R	LW	3
Hosmer's Spiny-tailed Skink	*Egernia hosmeri*	R,AG	LW,OPW	3
Northern Dwarf Skink	*Menetia maini*	R	LW	3
Lined Fire-tail Skink	*Morethia ruficauda*	R,LH,O	LW,SW	1
Wotjulum Soil-crevice Skink	*Notoscincus (ornatus) wotjulum*	R	LW,GRF	2
Common Blue-tongue Lizard	*Tiliqua scincoides*	LH	GRF	3
Typhlopidae				
Northern Blind Snake	*Ramphotyphlops diversus*	R,LH	OPW	3
Claw-snouted Blind Snake	*Ramphotyphlops unguirostris*	R	OPW	3
Boidae				
Children's Python	*Antaresia childreni*	R,LH,AG,O	OPW,SW,LW,C	1
Black-headed Python	*Aspidites melanocephalus*	R,LH,AG,O	GRF,SW,LW	1
Olive Python	*Liasis olivaceus*	R,LH,AG,O	GRF,SW,LW	*
Carpet Python	*Morelia spilota*	R	OPW	3
Acrochordidae				
Arafura File Snake	*Acrochordus arafurae*	R,LH,AG,O	Aq	1
Colubridae				
Green Tree Snake	*Dendrelaphis punctulata*	R,LH, AG,O	GRF	1
Keelback	*Tropidonophis mairii*	R,LH,AG,O	Aq	1
Macleay's Water Snake	*Enhydris polylepis*	R,LH,AG,O	Aq	1
Elapidae				
Northern Simoselaps	*Brachyurophis incinctus*	LH	OPW	3
Olive Whipsnake	*Demansia olivacea*	R,LH	OPW,SW	2
Collared Whipsnake	*Demansia flagellatio*	LH	SW	3
Black Whipsnake	*Demansia vestigiata*	LH	GRF	3
Unidentified Whipsnake	*Demansia sp. cf. olivacea*	LH	OPW,SW	2
Orange-naped Snake	*Furina ornata*	R,LH	OPW	1
Mulga Snake	*Pseudechis australis*	R,LH,AG	OPW	3
Ingram's Brown Snake	*Pseudonaja ingrami*	R,LH	LW,SW	2
Speckled Brown Snake	*Pseudonaja guttata*	LH	OPW	3
Western Brown Snake	*Pseudonaja nuchalis*	LH	OPW	3
Curl Snake	*Suta suta*	R,LH	OPW	2
Northen Bandy Bandy	*Vermicella annulata*	R,LH,AG	OPW,LW,GRF	2

Codes Used: Areas

R = Riversleigh World Heritage Area; LH = Lawn Hill (Boodjamullah National Park), AG = Adels Grove, O = others.

Habitats

Aq = Aquatic, GRF = Gallery Rainforest, LW = Limestone Woodland, OPW = Open Plains Woodland, SW = Sandstone Woodland; C = Caves

Abundance

1 = encountered during each survey year; 2 = encountered during two or three survey years; 3 = encountered only during one survey year. * abundance greatly decreased since arrival of Cane Toads.

Table 4. List of Frogs from Survey Areas

Common Name	Species	Areas
Hylidae		
Northern Water Holding Frog	*Cyclorana australis*	Adels Grove, Riversleigh floodplains, Louie Creek floodplain
Knife-footed Water Holding Frog	*Cyclorana cultripes*	Floodplains near mesas and near Lawn Hill-River sleigh boundary
Long-footed Water Holding Frog	*Cyclorana longipes*	Lagoon, north of Lawn Hill Station homestead
Common Green Tree Frog	*Litoria caerulea*	Widespread. In most vegetated areas along rivers and creeks, homesteads
Saxicoline Tree Frog	*Litoria coplandi*	Widdalion Falls and spring, Stick Figure Gorge, Gorge Spring.
Peter's Frog	*Litoria inermis*	Very common. On all rivers and creeks in the area
Rocket Frog	*Litoria nasuta*	Uncommon. Widdalion Creek, Lawn Hill Station.
Pale Frog	*Litoria pallida*	Uncommon. Gregory River crossing, OShanassey River crossing.
Northern Laughing Frog	*Litoria rothii*	Widespread. Along all water ways where there is floating or emergent vegetation.
Electric Tree Frog	*Litoria electrica*	Widespread. Most common around homestead, showers blocks, toilets etc,
Wotjulum frog	*Litoria wotjulumensis*	Common along major creeks and rivers.
Broad-palmed frog	*Litoria latopalmata*	Gregory River and Louie Creek.
Myobatrachidae		
Ornate Burrowing Frog	*Limnodynastes ornatus*	Common along permanent water ways, especially the Gregory River
Northern Spadefoot Frog	*Notaden melanoscaphus*	Uncommon. Only known from one clay pan site near mesas.
Bufonidae		
Marine Toad	*Bufo marinus*	Widespread. Not confined to rivers or creeks but present on plateaux and in caves.

Impact of Cane Toads

Reptile species that disappeared following the arrival of Cane Toads in the survey area are listed in Table 5.

Table 5. Reptile species in decline following the arrival of Cane Toads

Species	Observation
Freshwater Crocodile	Not detected at site from 1988 to 1995. Present since then but in very low numbers.
Olive Python	Not detected at site from 1988 to 1999. One animal seen since then. Previously very common.
Merten's Water Monitor	Not detected since 1988.

Figure 5. Undescribed Gecko *Gehyra* sp 1. Lawn Hill Gorge.

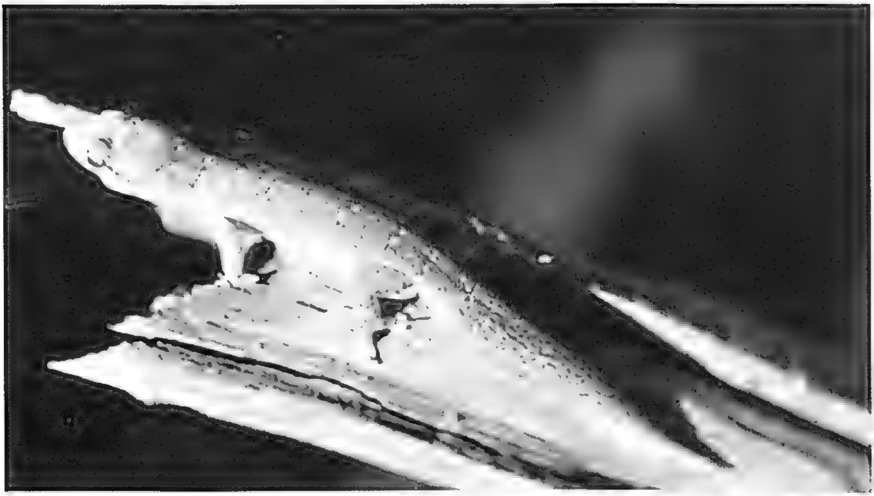


Figure 6. Ingram's Brown Snake *Pseudonaja ingrami*, the most common large elapid in the survey area.

present in many areas where overlying sedimentary layers have been eroded down to harder basal rock layers.

The high diversity of insectivorous and omnivorous lizards (Figure 5) is able to support a high diversity of terrestrial predatory reptiles. With the exception of a few species of aquatic snakes, most of the snakes in the survey areas are lizard hunters (Cogger, 2000; Figure 6)

The aquatic ecosystems are not as species rich as the terrestrial habitats for reptiles. Three aquatic snakes (1 acrochordid and 2 colubrids, including *Tropidonophis*) are present along with Freshwater Crocodiles and four species of turtles. The lower diversity in aquatic reptiles is made up for by their much greater abundance and body size. Most of the aquatic species are regularly encountered (Table 3) during surveys and all are active throughout the year.

Frogs

Frog diversity was not as great as that for reptiles. Three families of amphibians (including the introduced bufonid *Bufo*) are represented and a total of 15 species is present (Table 4). The dominant family is the Hylidae with 12 species. It is also the most diverse family with burrowing frogs that inhabit the dry floodplains and tree frogs that inhabit the gallery rainforest that fringes the rivers and creeks in the area (Figure 7). Ground Frogs (Myobatrachidae) are relatively uncommon, only two species are present and only one of these is commonly encountered.

Figure 7. Wotjulum Frog *Litoria wotjulumensis* is a common inhabitant of river banks and larger waterholes.

Impact of Cane Toads

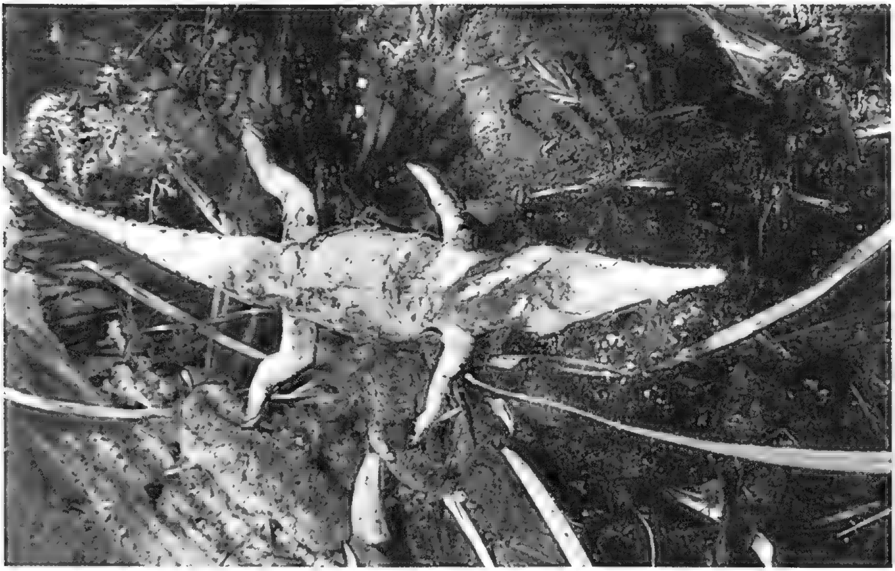
The arrival of Cane Toads at Gregory Camp had a dramatic and lasting impact on the reptile fauna. Within 12 months of their arrival three species of large aquatic/riparian reptile had disappeared from the area; all three had previously been widespread and common (Table 5). One of these species has not returned to the area.

The impact of cane toads was also visually apparent as rotting freshwater crocodile carcasses were present in all of the waterways in 1988 but no live crocodiles were seen (Figure 8). Dead freshwater crocodiles still occur in waterways at Boodjamulla and Riversleigh but these are usually small crocodiles, less than 70 cms in total body length. In June 2002, for example, four small dead crocodiles were found in Lawn Hill Creek. Three were relatively fresh and the bellies were cut open to reveal the gut contents. All three had cane toads in their stomachs. Another dead small crocodile was found at Louie Creek in the same year and it also had cane toads in its stomach. The rarity of dead adult freshwater crocodiles suggest that adult crocodiles have become more circumspect about feasting on cane toads and only the unwary juvenile crocodiles are still liable to consume lethal numbers of toads. It may also reflect less susceptibility to toad toxins by larger animals as well as a dietary shift with age.

Dead Olive Pythons and Merten's Water Monitors were not found in abundance in the wake of the arrival of cane toads. As both species disappeared, it is assumed that the dying animals had crawled under shelter to die.

Another species of goanna, Mitchell's Water Monitor, appears to have also disappeared as a result of cane toads. This monitor was

Figure 8. Dead Freshwater Crocodile *Crocodylus johnstoni*. Louie Creek, June 1999.



present on Lawn Hill Creek prior to the arrival of Cane Toads but has not been recorded there since 1987 (QNPWS records).

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REFERENCES

Archer, M., Godthelp, H., Hand, S. & Megirian, D. 1989. Fossil mammals of Riversleigh, northwestern Queensland: Preliminary overview of biostratigraphy, correlation and environmental change. Australian Zoologist 25(2):29-65.

Archer, M., Hand, S. & Godthelp, H. 1991. Riversleigh. The Story of Animals on

Ancient Rainforests of Inland Australia. Reed Books, Balgowlah.

Bean, T. 1991. Report on the vegetation of Riversleigh. Queensland National Parks and Wildlife Service.

Cogger, H.G. 2000. Reptiles and Amphibians of Australia. 6th edn. Reed New Holland Books, Frenchs Forest.

Cogger, H.G. & Heatwole, H. 1981. The Australian reptiles: origins, biogeography, distribution patterns and island evolution. Pp. 1331-1373 in, Keast, A. (ed.) Ecological Biogeography in Australia. W. Junk, The Hague.

Horner, P. 1995. Amphibians and reptiles of Musselbrook Reserve, northwestern Queensland. Pp. 139-152 in, Musselbrook Reserve Scientific Study Report. Royal Geographic Society of Queensland Inc., Brisbane.

McKay, L. & Clarke, R.H. 1999. Some reptile range extensions at Lawn Hill National Park, Gulf of Carpentaria, Queensland. Herpetofauna 29(1): 21-24.

O'Keefe, C. 1996. Discover Lawn Hill National Park. Robert Brown and Associates, Coorparoo.

Thomson, S., White, A.W. & Georges, A. 1997. Re-evaluation of *Emydura lavarackorum*: identification of a living fossil. Memoirs of the Queensland Museum 42: 327-336.

White, A.W. & Archer, M. 1994. *Emydura lavarackorum*, a new pleistocene turtle (Pleurodira:Chelidae) from fluviatile deposits at Riversleigh, northwestern Queensland. Records of the South Australian Museum 27: 159-167.

White, A.W. 1999. Initial observations and survey results of freshwater turtles in the Gregory River and Lawn Hill Creek, northwestern Queensland. Herpetofauna 29(2): 37-48.

NOTES ON THE USE OF TAIL DISPLAYS AS AN ANTI-PREDATOR TACTIC OF THE RED-BELLIED BLACK SNAKE, *PSEUDECHIS PORPHYRIACUS* (SERPENTES: ELAPIDAE)

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INTRODUCTION

Tail waves or vibrations form a significant component of anti-predator displays in a variety of snake species, the most well known and specialised example being that of the American Rattlesnakes, *Crotalus* spp. (Greene, 1988). Caudal luring, a more fluid undulation of the tail, may also be employed during defensive strategies, in attempts to either divert the predator's attention away from the head (e.g. Pough, 1988), or to induce movement by the predator, assisting the prey animal to maintain visual contact with the perceived threat (the 'come-on response'; Magnusson, 1996). So far, however, few instances of defensive tail luring behaviour have been documented in Australian snakes (although several species may employ similar tactics to assist prey capture, including *Demansia psammophis, Elapognathus* [formerly *Drysdalia*] *coronatus, Morelia viridis*, and most notably *Acanthophis* spp.; Chiszar *et al.*, 1990; Barker & Barker, 1994; Greer, 1997; Scanlon, 1998). The following paper describes tail movements observed during anti-predator displays of the Red Bellied Blacksnake, *Pseudechis porphyriacus*, and discusses their apparent use as a caudal lure.

OBSERVATIONS

All observations were made within a 5 km² study area surrounding the Mt Meg Flora and Fauna Reserve, a granite massif located approximately 22 km west of Wangaratta in north-eastern Victoria (36°23'S 146°05'E). Ten specimens of *P. porphyriacus* were observed whilst traversing this area on foot, four days each week between September 2000 and March 2001 (Heard & Black, 2003). Observations of rhythmic tail movements during anti-predator displays were made from three snakes located during the first week of November, coinciding with an apparent peak in spring activity.

1.

Date: 2 November 2000

Time: 1500 hrs

Weather Conditions: Mild sunny afternoon, clear skies, ca. 20°C.

Habitat: A narrow strip of open riparian woodland on the western bank of a small, spring fed stream; vegetation dominated by White Box, *Eucalyptus albens*, and Lightwood, *Acacia implexa*.

Notes: An adult *P. porphyriacus* (ca. 1.3 m total length) was observed moving through tussock grasses, three metres above the creek-bed (which formed a relatively deep, eroded gully at this site). The specimen was approached from behind and followed at a distance of 1.5 metres, for around five metres. After this distance, the snake became aware of my presence; the head was turned to the left so that I was in the direct field of view and the animal 'froze'. The snake remained completely immobile for some 15 seconds before the tail was raised above the ground (ca. 5 cm) and moved in a rhythmic, undulating fashion for approximately 30 seconds. The display consisted of continuous lateral undulations of the raised tail section (roughly the terminal 10 cm of the tail). Each movement originated at the anterior end of the tail and swept through to the tail tip over the course of one to two seconds. Speed of

these movements was consistent throughout the display. At all times the tail was held away from the substrate, and no other movement was noted in the snake's body; therefore no noise was audible throughout the display. The tail display was terminated gradually (by slowing the rate of movement) until the snake was once again completely immobile. It remained in this position for another 15 seconds (approximately) before thrashing the body violently and quickly fleeing through the adjacent vegetation. This thrashing motion consisted of a swift take-off in which the first third of the body was raised off the ground and the later two thirds undulated wildly to propel the snake forward and away from myself. I remained completely still during the entire process.

2.

Date: 3 November 2000

Time: 1615 hrs

Weather Conditions: Clear, sunny conditions with a slight breeze, ca. 24°C.

Habitat: An open, eroded site between a series of sewage settling ponds and a large, spring-fed water body surrounded by a dense growth of Prickly Tea-Tree, *Leptospermum continentale*, with an overstory of River Red Gum, *E. camaldulensis*.

Notes: A large, heavily-built *P. porphyriacus* (ca. 1.8 m TL) was located crossing a small clay-pan with little surrounding vegetation. The snake was approached to within one metre, during which time it ceased all movement (this animal had seen my approach due to the open nature of the locality). The specimen displayed precisely the same pattern of behaviour exhibited by the first individual. The tail tip was raised above the substrate shortly after my approach and wiggled in the same manner as described above. The tail display was extinguished some 30 seconds later when no response was elicited, and followed by the rapid, thrashing escape behaviour. Again, I remained completely still during the entire observation period.

3.

Date: 7 November 2000

Time: 1417 hrs

Weather Conditions: Low cloud cover, sunny, ca. 25°C.

Habitat: Very similar to that of the first specimen, being located roughly 200 m north along the same creek-line. Several large River Red Gums, *E. camaldulensis*, were present at this site.

Notes: The scenario recorded here is very similar to the first observation. Whilst approaching the gully from the west, a moderately large (ca. 1.5 m TL) *P. porphyriacus* was seen heading south through open grasses above the creek-line. The specimen was approached from behind and quickly became aware of my presence, ceasing movement. Lateral undulations of the tail tip were displayed as described previously; however, this specimen simultaneously displayed some aggression in the form of a low-held, expanded neck display (the 'partial neck display' of Whitaker & Shine, 2000). This snake moved slightly forward during the next 15 seconds (continued tail and hood display), before bursting forward and away following the same pattern as snakes one and two.

DISCUSSION

The observations presented above show a consistent method of anti-predator defense within this population of *P. porphyriacus*. When stalked in relatively open localities, snakes ceased all movement (froze) upon recognising the predatory threat, conducted a brief tail waving display, and concluded by thrashing the body wildly before fleeing the predatory threat.

Ceasing movement is a common response of many active elapid snakes (and indeed squamates in general) to the recognition of a predatory threat (Greene, 1988; Greer, 1997), and presumably is used to either prevent any immediate attack by removing the movement stimulus, or to allow the

animal to assess the position and movement of the potential predator. Tail movements were employed after this initial behaviour and consistently appeared to act as a lure to the potential predator (myself). The action seen here was quite fluid and, although slower, similar to caudal luring displays of *Acanthophis* spp. (pers. obs). As such, the actions seen were markedly different to the tail-twitching behaviour displayed by some snakes when aroused (pers. obs) (see Greer, 1997), and thus, represent a functionally significant component of the anti-predator display. In each of the encounters described, a 'stand-off' situation arose as neither I, or the snake fled upon the initial encounter. Fitting with the 'come-on' response of Magnusson (1996), caudal luring appeared an attempt to break this stand-off by provoking a response from myself. Making a predator act in such a situation may allow the animal to visually assess the predator's attack, and respond through rapid avoidance behaviour or counter-attack (e.g. a well placed strike). Finally, the rapid, thrashing escape behaviour appears to be a 'startle tactic' and was employed only after ceasing the tail display (which elicited no response). Behavioural and morphological tactics that startle potential predators may significantly improve a prey animal's ability to escape and have been documented in a wide range of vertebrate and invertebrate groups (e.g. Krebs & Davies, 1993). The distinctive red ventral scales of this species may play some role in this regard, although they remained largely obscured during these observations.

If the interpretation provided above is valid, under what circumstances might this behaviour be most advantageous? The defensive ploys used by snakes are often varied depending upon the habitat occupied during a predatory encounter (Senter, 1999; Whitaker & Shine, 1999). It is apparent that the tactics described here may be employed primarily when these snakes encounter predators in relatively open habitats, particularly where the predator is actively stalking the snake (each of the observations described above match this situation). For example, I observed three different blacksnakes display a simple fleeing tactic at this site. Each of these specimens was encountered in, or very close to dense cover (a stand of Cumbungi, *Typha* sp., for two snakes; a well-vegetated rock scree for the other), and 'predator' and prey located each other simultaneously. Another two specimens showed a partial defense display, they froze before displaying the 'startle tactic'. Both were located on open ground but were able to retreat to significant cover within two metres (a log and thick grass respectively). Therefore, the display recorded here, particularly the use of caudal luring, may be primarily used when these snakes are exposed and have little chance of escape. In this case, it may be particularly relevant for males.

While sex was not determined for any of the blacksnakes observed at the Mt Meg study area, the large size and spring movement patterns of the three displaying animals suggests they were males (Shine, 1991). It is possible that the defensive ploys described here are used primarily by this sex when on mate-searching forays, away from significant cover and the familiar environment of their core home-range. Replicated, standardised encounters would be required to determine if the defensive ploys of these blacksnakes are related to sex, season or habitat conditions, or an interaction of these factors (see Whitaker & Shine, 1999).

The defensive ploys of *P. porphyriacus* have been poorly documented across the geographic range of the species, limiting comparisons between populations. While tail vibrations have been previously recorded in the defensive repertoire of blacksnakes (Johnson, 1975), the sequence of behaviour described here has not been recorded during studies on the ecology of this species across New South Wales (R. Shine, P. Harlow, pers. comm.), or documented from other sections of this snake's extensive geographic range. The origin and persistence of these behaviours may therefore be dependent on local

environmental factors, such as habitat attributes and/or predatory stresses. My study area is characterised by a mosaic of woodland and open farmland habitats, in which varanids are abundant (see Heard & Black, 2003). While it is probable that the defensive ploys described here are widespread, the dual threats of a fragmented environment and an abundance of these visual predators may enhance the use of this behaviour at Mt Meg.

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REFERENCES

Barker, D.G. & Barker, T.M. 1994. Pythons of the World. Volume 1: Australia. Advanced Vivarium Systems Inc., California.

Chiszar, D., Boyer, D., Lee, R., Murphy, J.B. & Radcliffe, C.W. 1990. Caudal luring in the southern death adder, *Acanthophis antarcticus* (Reptilia, Serpentes, Elapidae). Journal of Herpetology 24(3): 253-260.

Greene, H.W. 1988. Anti-predator mechanisms in reptiles. Pp. 1-152 in, Gans, C. & Huey, R.B. (eds.). Biology of the Reptilia. Vol. 16: Ecology B. Academic Press Inc., New York.

Greer, A.E. 1997. The Biology and Evolution of Australian Snakes. Surrey Beatty and Sons, Chipping Norton.

Heard, G.W. & Black, D. 2003. A survey of the reptile fauna inhabiting the Mt Meg Flora and Fauna Reserve, north-east Victoria. Victorian Naturalist 120(3): 84-91.

Johnson, C.R. 1975. Defensive display behaviour in some Australian and Papuan-New Guinean pygopodid lizards, boid, colubrid and elapid snakes. Zoological Journal of the Linnean Society 56: 265-282

Krebs, J.R. & Davies, N.B. 1993. An Introduction to Behavioural Ecology. Blackwell Scientific Publications, Oxford.

Magnusson, W.E. 1996. Tail and hand waves: a come-on for predators? Herpetological Review 27(2): 60.

Pough, F.H. 1988. Mimicry and related phenomena. Pp.153-234 in, Gans, C. & Huey, R.B. (eds.). Biology of the Reptilia. Vol. 16: Ecology B. Academic Press, New York.

Scanlon, J.D. 1998. Prey-scaring by visual pursuit predators: a new use for tail-waving in snakes. Herpetofauna 28(2): 5-10.

Senter, P. 1999. The visibility hypothesis: an explanation for the correlation between habitat and defensive display in snakes. Herpetological Review 30(4): 213.

Shine, R. 1991. Australian Snakes. A Natural History. Reed Books, Sydney.

Whitaker, P.B. & Shine, R. 1999. Responses of free-ranging brownsnakes (*Pseudonaja textilis*: Elapidae) to encounters with humans. Wildlife Research 26: 689-704.

Whitaker, P.B. & Shine, R. 2000. The defensive strike of the eastern brownsnake, *Pseudonaja textilis* (Elapidae). Functional Ecology 14: 25-31.

RESULTS OF A SURVEY OF THE AMPHIBIAN FAUNA OF MOOLOOLAH RIVER NATIONAL PARK

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INTRODUCTION

Mooloolah River National Park (hereby referred to as 'the Park') is an 830 hectare conservation reserve located within Maroochy Shire on the Queensland Sunshine Coast (26°42'S 153°04'E). The Park is the second largest mainland Park in the southeast Queensland coastal lowlands, next to Noosa National Park. The Park is considered to be the best remaining sample of coastal lowland vegetation found within Maroochy Shire and forms part of one of the largest remaining areas of valuable habitat left on the Sunshine Coast (QPWS, 2000).

The Park conserves an example of the low-lying, gently undulating coastal floodplain landform which is distinctive to the Sunshine Coast. The geology is predominantly Quaternary sands with areas of Landsborough sandstone. A diversity of coastal lowland vegetation is represented in the Park, including open heath, eucalypt forest and mangrove forest fringing the Mooloolah River.

The vertebrate fauna of the Park (including amphibian fauna) was described by Krieger (1995), who identified the occurrence of four amphibian species within the reserve: the Wallum Froglet (*Crinia tinnula*), Striped Marsh Frog (*Limnodynastes peronii*), Red-backed Toadlet (*Pseudophryne coriacea*) and Cane Toad (*Bufo marinus*).

Amphibian surveys were also conducted by Ecological Management Services (1998) in an area of land which has recently been added to the Park. Species recorded were the Wallum Froglet, Striped Marsh Frog, Northern Banjo Frog (*L. terraereginae*), Wallum Rocket Frog (*Litoria freycineti*), Rocket Frog (*Litoria nasuta*), Broad-palmed Frog (*Litoria latopalmata*), Wallum Sedgefrog (*Litoria olongburensis*), Dainty Tree Frog (*Litoria gracilenta*) and Cane Toad.

At a regional level the amphibian species which occur in coastal south-east Queensland are well documented. Nevertheless, on a Park by Park basis the amphibian fauna has not been adequately documented. In particular, the amphibian fauna of Mooloolah River National Park had only a handful of species recorded within its boundaries.

METHODS

Amphibians were surveyed opportunistically from existing walking tracks and roadside survey on the following dates: 30/10/00, 1/11/00, 2/11/00, 3/11/00, 10/10/01, 17/10/01 and 22/10/01. A relatively small percentage of the Park area was sampled (approximately 25%) and most effort was concentrated on accessible areas. Survey methods employed were active searching and auditory recognition. Frogs were identified using Barker *et al.* (1995).

RESULTS

A total of 21 species of amphibian was recorded from the Park during the survey period. The species recorded are listed below with brief notes on their abundance within broad habitats. Rankings given were: abundant (>100 individuals observed in each survey), common (20-100 individuals observed in each survey), uncommon (10-20 individuals observed in each survey) and rare (<10 individuals observed in each survey). Status is as per the Queensland Nature Conservation (Wildlife) Regulation (1994). The amphibian fauna of the Park have not been subject to systematic survey. Objective estimates of abundance are therefore not possible.

Table 1. Species recorded from Mooloolah River National Park

Scientific Name	Common Name	Status	Method
Myobatrachidae			
Crinia signifera	Common Eastern Froglet	C	A
Crinia tinnula	Wallum Froglet	V	A, V
Limnodynastes ornatus	Ornate Burrowing Frog	C	A, V
Limnodynastes peronii	Brown-striped Frog	C	A, V
Limnodynastes tasmaniensis	Spotted Marsh Frog	C	A, V
Limnodynastes terraereginae	Northern Banjo Frog	C	A, V
Pseudophryne raveni	Copper-backed Brood Frog	C	A, V
Uperoleia fusca	Dusky Toadlet	C	A, V
Hylidae			
Litoria caerulea	Green Tree Frog	C	A, V
Litoria dentata	Bleating Tree Frog	C	A, V
Litoria fallax	Eastern Dwarf Tree Frog	C	A, V
Litoria freycineti	Wallum Rocket Frog	R	A, V
Litoria gracilenta	Dainty Green Tree Frog	C	A, V
Litoria latopalmata	Broad-palmed Frog	C	A, V
Litoria nasuta	Rocket Frog	C	A, V
Litoria olongburensis	Wallum Sedgefrog	V	A, V
Litoria peronii	Emerald-spotted Tree Frog	C	A, V
Litoria rubella	Desert Tree Frog	C	A, V
Litoria tyleri	Laughing Tree Frog	C	A, V
Litoria verreauxii	Whistling Tree Frog	C	A, V
Bufonidae			
Bufo marinus	Cane Toad	I	A, V

Abbreviations:

Status

I = Introduced, C = Common, V= Vulnerable as per the Queensland Nature Conservation (Wildlife) Regulation (1994).

Method

A= Auditory recognition, V = Visual record

Scribbly Gum (*Eucalyptus racemosa*) open forest and woodland communities with a shrubby understorey (e.g. *Banksia integrifolia, Jacksonia scoparia, Hovea acutifolia*) and a grassy or open ground cover occur over much of the Park. Species recorded in this habitat type were: Common Eastern Froglet (abundant), Copper-backed Broodfrog (common), Brown-striped Frog (common), Spotted Marsh Frog (uncommon), Emerald-spotted Tree Frog (common), Desert Tree Frog (common), Dainty Green Tree Frog (uncommon), Eastern Dwarf Tree Frog (common), Broad-palmed Frog (common), Green Tree Frog (uncommon) and Rocket Frog (common).

Scribbly Gum (*Eucalyptus racemosa*) open forest and woodland communities with *Banksia oblongifolia*/sedge understorey occur on the slightly elevated margins of wetter sites within the Park. Species recorded in this habitat type were: Wallum Froglet, Copper-backed Broodfrog, Northern Banjo Frog and Rocket Frog (all four common).

Broad-leaved paperbark (*Melaleuca quinquenervia*) open forest/woodland with a shrubby midstorey and a grassy or open ground cover occurs on seasonally waterlogged but slightly elevated sites. Species recorded in this habitat type were: Copper-backed Broodfrog (common), Emerald-spotted Tree Frog (common), Laughing Tree Frog (uncommon), Dainty Green Tree Frog (common), Eastern Dwarf Tree Frog (common), and Rocket Frog (common).

Broad-leaved paperbark (*Melaleuca quinquenervia*) open forest/woodland occurs on wetter sites with sedges, Swamp water fern (*Blechnum indicum*) and shrubs (*Callistemon pachyphyllus* and *Melastoma affine*). Species recorded in this habitat type were: Wallum Froglet (common), Copper-backed Broodfrog (common), Wallum Sedgefrog (common), Wallum Rocket Frog (uncommon) and Whistling Tree Frog (rare).

Swamp Banksia (*Banksia robur*) closed heaths occur on low lying areas and are generally wet heaths. Species well represented include *Empodisma minus, Sprengelia sprengelioides, Melaleuca thymifolia, Boronia falcifolia* and *Epacris microphylla*. Species recorded in this habitat type were: Wallum Froglet (abundant), Northern Banjo Frog (common), Dusky Toadlet (uncommon), Ornate Burrowing Frog (rare), Wallum Rocket Frog (common) and Wallum Sedgefrog (common).

Sedgelands occur on permanently wet areas and form the drainage depressions of the area. Prominent species are *Baumea articulata* or *Lepironia articulata* in pure stands in the wettest areas with *Baumea rubiginosa* sometimes present. In less wet areas *Callistemon pachyphyllus* and *Blechnum indicum* occur. Species recorded in this habitat type were: Wallum Froglet and Wallum Sedgefrog (both abundant).

DISCUSSION

During the course of the survey three species were detected which are recognised as threatened species in State or Commonwealth legislation: the Wallum Froglet (*Crinia tinnula*), Wallum Sedgefrog (*Litoria olongburensis*) and Wallum Rocket Frog (*Litoria freycineti*). These three species, and a fourth species (*Litoria cooloolensis*), are collectively known as Wallum or acid frogs (Ingram & Corben, 1975).

At a statewide level, the Wallum Froglet, Wallum Sedgefrog and Wallum Rocket Frog are listed as Vulnerable species in the Queensland Nature Conservation (Wildlife) Regulation (1994). At a national level, the Wallum Sedgefrog is listed as a Vulnerable species in the Environment Protection and Biodiversity Conservation Act (1999).

Mooloolah River National Park is significant in that it supports sizeable populations of each of the three Vulnerable acid frog species known from mainland Queensland south of Noosa Shire. A review of the distribution of these species presented in Hines *et al.* (1999) indicates that there are no extant populations of the Wallum Sedgefrog between Brisbane

and the NSW-Qld border on the mainland and the situation is similar for the Wallum Rocketfrog. Mainland populations of the Wallum Froglet are also very restricted in occurrence between Maroochy Shire and the NSW-Qld border.

The occurrence of the Whistling Treefrog *Litoria verreauxii* in this locality is unusual, given that the species is primarily restricted to the Great Dividing Range in Queensland. The site locality is outside the mapped distribution of *L. verreauxii* in Cogger (1996), Barker *et al.* (1995) and Robinson (1998). The specimen was identified initially by call, and was captured and keyed to *L. verreauxii* in the aforementioned texts. Populations of this species are also present in coastal northern NSW (Alstonville District) (pers. obs.), suggesting that the published distribution of *L. verreauxii* requires review.

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REFERENCES

Barker, J., Grigg, G. & Tyler, M.J. 1995. A Field Guide to Australian Frogs. Surrey Beatty and Sons, Chipping Norton, NSW.

Cogger, H.G. 1996. Reptiles and Amphibians of Australia. Sixth Edn. Reed New Holland, Sydney.

Ecological Management Services 1998. Assessment of the Acid Frogs of the Moreton Mill Land, Mountain Creek. Unpublished report.

Hines, H., Mahony, M. & McDonald, K. 1999. An assessment of frog declines in wet subtropical Australia. Pp. 44-63 in Campbell (ed.). Declines and Disappearances of Australian Frogs. Environment Australia, Canberra.

Ingram, G.J. & Corben, C.J. 1975. The frog fauna of North Stradbroke Island, with comments on the 'acid' frogs of the Wallum. Proceedings of the Royal Society of Queensland 86(9): 49-54.

Krieger, G. 1995. A vertebrate fauna survey of Mooloolah River National Park, south-east Queensland. Unpublished report.

Queensland Parks and Wildlife Service 2000. Management Plan, Mooloolah River National Park. Queensland Environmental Protection Agency, Brisbane.

Robinson, M. 1998. A Field Guide to Frogs of Australia from Port Augusta to Fraser Island including Tasmania. Reed New Holland, Sydney

SURVEYS FOR AND HABITAT ASSESSMENT OF THE GREEN AND GOLDEN BELL FROG *LITORIA AUREA* ON THE FAR SOUTH COAST OF NEW SOUTH WALES

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ABSTRACT

Evidence from museum collections and long-time residents indicate that the Green and Golden Bell Frog *Litoria aurea* was wide-spread and abundant on the far south coast of NSW South Wales prior to the 1980s. In order to assess the current status of the species targeted surveys were conducted from December 2000 to February 2001 and 16-17 January 2002 at coastal locations from the Victoria/New South Wales border north to Batemans Bay. During that period 130 sites were surveyed. Seventy one of these sites were visited both during the day and night. Twenty four of the sites were visited during the day only and 35 were only visited during the night. Twenty five of the known 34 historic sites were surveyed. The total survey effort totalled approximately 24 hours nocturnal and 64 hours diurnal surveys. *Litoria aurea* were detected at Tura Beach, close to a sew-erage treatment plant and during follow up surveys at Nadgee Nature Reserve in flooded coastal paperbark *Melaleuca ericifolia* swamp.

The Plague Minnow *Gambusia holbrooki* is listed under Schedule 3 of the Threatened Species Conservation Act 1995 as a key threatening process. *Gambusia holbrooki* was detected at 16 sites (12% of sites surveyed).

INTRODUCTION

Litoria aurea is listed on Schedule 1 of the Threatened Species Conservation (TSC) Act 1995 as Endangered and Schedule 1, Part 2 of the Environment Protection and Biodiversity Conservation Act (EPBC) 1999 as Vulnerable.

The species was once one of the most commonly encountered frogs on the east coast and southern tablelands of New South Wales (NSW) (Osborne *et al.*, 1996). The species' distribution ranged from Tyagarah Nature Reserve in the north (in ponds created from sand mining (M. Fitzgerald, pers. comm.) to east Gippsland in the south (Gillespie, 1996). However, since about the 1980s the species has had a rapid decline in distribution and abundance over much of its range.

Litoria aurea is known from only about 40 sites in NSW (White & Pyke, 1996), the vast majority of which lie within one kilometre of salt water. One extant population is known on the southern tablelands, near Queanbeyan (Wassens & Mullins, 2001). Another inland population occurs in the Hunter Valley around sewage treatment ponds, near Lake Liddell (G. Daly, pers. obs.).

In NSW populations have been detected within the last five years from Yuragir and Hat Head in northern NSW south to Nadgee Nature Reserve (NR). These populations are isolated and often small. In the last decade only a few specimens have been detected between Batemans Bay and the New South Wales/Victorian border.

The documented decline and paucity of information on the *Litoria aurea* on the far south coast of NSW prompted the NSW National Parks and Wildlife Service to initiate surveys in the 'gap' regions of coastal NSW.

The aim of our survey was to assess historic and potential sites to determine the current status of *L. aurea* on the far south coast of NSW. Surveys were also conducted for the Plague Minnow *Gambusia holbrooki* as this species eats spawn and tadpoles (Morgan &

Buttemer, 1996; Pyke & White, 2000). *Gambusia holbrooki* is listed as a Key Threatening Process under Schedule 3 of the TSC Act 1995 and is considered one cause for the apparent decline or disappearance of *L. aurea* at some sites. The survey of gap regions on both the north and south coast was considered a desired action of the draft Recovery Plan for this species during its formulation (NSW NPWS, in prep.).

METHODS

Survey area

The survey area (Figures 1-2) extended from Batemans Bay (34°33'S 150°39'E) in the north to the New South Wales/Victorian border (37°18'S 150°45'E). Surveys were conducted at sites where *L. aurea* had previously occurred (historic sites) and in other sites that occurred near coastal wetlands and contained areas of emergent macrophytes (potential sites).

Site Selection

Prior to fieldwork previous records of *L. aurea* were reviewed. The records reviewed included those from the NSW NPWS Wildlife Atlas (including CSIRO, Australian Museum, and State Forests of NSW records) and unpublished data held by the senior author (GD). These records were marked on 1: 25000 topographic maps and 21 of the 34 (62%) were surveyed during this project. Some sites were not surveyed because of difficulty with access (freehold land) and/or were a distance from the coast and hence considered unlikely to support *L. aurea*.

One hundred and seven survey sites were selected by viewing topographic maps and locating wetlands, dams, quarries and sewerage treatment plants that were accessible by road and close to the coast. Most current records are from coastal locations hence survey effort was focused at sites where the species was considered most likely to still persist.

Survey Periods and weather conditions

The survey was conducted over five separate periods (10-15 December 2000, 9-11 January 2001, 22-25 January 2001, 4-9 February 2001 and 16-17 January 2002). Weather conditions varied considerable during the survey. In general the survey area experienced below average rainfall during the survey as evidenced by the low water levels in swamps. There was little or no cloud cover during the December 2000 and February 2001 surveys. Overcast conditions occurred during many of the surveys conducted in January 2001. The January 2002 surveys were conducted two days after the area had experienced approximately 70 mm rain.

One historic site at Nadgee Nature Reserve was resurveyed on 24-25 October 2002, 15 October 2002 and 4 November 2002 by Ms L. Evans (NSW NPWS) during the day.

Diurnal Searches

Diurnal searches involved walking around suitable waterbodies and looking for basking frogs. The call of *L. aurea* was broadcast during surveys. Species were identified by direct observation of frogs and tadpoles, and by recognition of calls (Appendix). Ponds were dip netted for tadpoles and fish.

Nocturnal Searches

Nocturnal searches involved spotlighting around the perimeter of waterbodies with the aid of fifty watt/12 volt spotlights. The survey consisted of a two-minute period in which unsolicited frog calls were noted followed by one-minute broadcast of *L. aurea* calls from a cassette player (Optimus CTR-116). If the sites were easily accessed or were of sufficient size then additional calls were played at intervals while spotlighting.

Surveys were conducted in the period between sunset and midnight with air temperatures between 17.3-28.0°C. Surveys were not conducted below this minimal temperature as it was considered unlikely that *L. aurea* would be calling or very active. Although dip netting was not conducted during nocturnal surveys the fish observed were identified and noted.

Interviews with long-term residents

The owners/managers of sites on freehold land were contacted prior to surveys. Facts sheets on *L. aurea* (NSW NPWS publication) were given to approximately 30 people. Residents were questioned if they had seen *L. aurea* on their land and asked to provide the date of last known sighting and an estimate of abundance.

Survey Hygiene

The NSW NPWS hygiene protocol for surveying frogs (NSW NPWS Threatened Species Management, 2000) was followed. In order to reduce the risk of infection and spread of amphibian chytrid (*Batrachochytrium*) fungus hands were thoroughly washed prior to surveys, endangered species of frog were not handled and other species of frog were rarely handled. Equipment such as dip nets and shoes were thoroughly cleaned with diluted bleach, prior to every day and night survey.

Habitat Assessment

The habitat of sites selected for nocturnal surveys was assessed. Details of location (grid reference), disturbance history (logging, fire, grazing, weeds), adjacent vegetation (height and species of canopy, midcanopy and shrublayer), depth of leaf litter and soil and water body characteristics (type of substrate, fringe vegetation, colour of water, depth of water, exposure to sun, estimated area of floating and emergent aquatic vegetation) were recorded.

RESULTS

Survey sites and survey effort

A total of 130 sites was surveyed (Appendix, Figures 1 and 2). One hundred and four sites were surveyed at night and 26 sites during the day. Seventy one of the sites were visited both during the day and night. Twenty four of the sites were visited only during the day and 35 of the sites were only visited during the night. The detection rate for *L. aurea* was zero of diurnal and 0.9% of nocturnal sites. The survey effort totalled approximately 24 hours nocturnal and approximately 64 hours of diurnal surveys.

The survey sites were categorised as follows: 16 (12%) were coastal lagoon sites, 35 (27%) were coastal swamps, 23 (17%) were river floodplains and 56 (43%) were miscellaneous water bodies/habitat comprising human constructed/altered features.

Of the 130 sites surveyed, 50% contained relatively undisturbed wetland vegetation and/or significantly modified immediate catchment. Twenty four sites contained expansive areas of habitat and it would be impossible to be certain that the species no longer persists there.

Assessment of historic *Litoria aurea* sites and information from local residents

Of the 34 historic *L. aurea* sites known for the south coast 25 (74%) were surveyed for approximately five hours during nocturnal surveys and one hour during diurnal surveys. The other nine sites were not surveyed (but four were assessed for habitat) because of problems with access, constraints of survey time or because they were considered to have unsuitable habitat. No *L. aurea* were found at historic sites during our survey (but see below for resurvey of Nadgee sites).

Interviews with long-term local residents indicated a perceived decline in abundance and distribution. Declines were noted from the early 1980s to the 1990s. For example, at Bobundara Swamp *L. aurea* was common up until the early 1990s (N. Hoye, pers. comm.) and widespread across the Murrah River flats (D. Rudd, pers. comm.). Both people suggested that *L. aurea* might still persist at these sites as they had seen frogs within the last few years.

Litoria aurea were common in wetlands around Pambula during the early 1980s (P. Johnson, pers. comm.) and there are specimens from this location in the Australian Museum collection (Table 1). However, the population declined during the 1980s (P.

Johnson, pers. comm.) and no animals have been detected in the area since that time.

South of Eden is the small township of Kiah and Mr J. Morris, resident since 1974, recalled large choruses of *L. aurea* emanating from Towamba Swamp until 1978. In June of that year Towamba River flooded and engulfed the wetland. The flood gouged out the wetland and as a result it changed from an ephemeral to a permanent waterbody (J. Morris, pers. comm.). Currently the Plague Minnow *Gambusia holbrooki* is present in Towamba Swamp and it is likely that the arrival of this fish is linked to that flood.

The general consensus from interviews with long term residents indicated that *L. aurea* was abundant on the far south coast of NSW till the late 1970s and drastically declined after that period (see Table 1).

Habitat Assessment of historic and current *L. aurea* sites

Surveys of historic sites indicated that on the south coast of NSW, *L. aurea* occurred primarily in low altitude wetlands within one kilometre of the sea (Table 2). However, the species also occurred in river valleys some distance from the coast. Large permanent or long standing wetlands and sedgeland/heath were the main habitat of *L. aurea*. Apart from the sedgeland/Swamp Paperbark *Melaleuca ericifolia* communities in Nadgee Nature Reserve, most historic sites had extensive areas of emergent macrophytic plants such as Cumbungi, Spikerush and Sawsedge. Visual assessments indicated minimal destruction or modification of habitat at most of the historic *L. aurea* sites.

The altitudinal range of the species at historic sites in the study region was 1-130 m above sea level (Australian Height Datum). The average altitude of these sites was 16.6 m (n = 29). Current sites (located within the last five years) have all been located below 40 m AHD. The only known extant sites on the south coast are close to sea level. The range of distance from the sea where *L. aurea* has been detected on the far south coast was between 0.1 – 13 km. The average distance from the sea was 1.6 km (n = 29).

The habitat assessment of sites from where *L. aurea* were previously known indicated an association with coastal wetlands, sandy substrates, shallow water (less than 1 m in depth), areas where emergent macrophytic species of plant were abundant, fish free ponds, and areas that receive direct exposure to sunlight for 3/4 of the day.

Exotic fish - a possible cause of population declines

Plague Minnow *Gambusia holbrooki* were detected at 16 sites (12% of sites surveyed). Anecdotal evidence suggested that *G. holbrooki* has had a negative impact on frog diversity and abundance. However, at some sites where *G. holbrooki* was present the frog species diversity was comparatively high (see Table 2). Other species of fish observed were Carp *Cyprinus carpio*, Eel *Anguilla* spp., Spotted Galaxia *G. maculata*, Gudgeons *Gobiomorphus* spp., Smelt *Retropinna semoni*, Mullet *Mugil cephalus* and Blue Eye *Pseudomugil signifer*.

Extant *Litoria aurea* site

Litoria aurea was detected at Tura Beach, close to the sewerage treatment plant (STP) on freehold land (the Tura Beach Golf Course). One animal (ca 80 mm snout-vent length) was observed during spotlight surveys adjacent to a small pond. Two frogs were also heard calling but could not be located. Further searches on the following day suggested that the calling males were most probably positioned within a pipe associated with the sewerage treatment plant.

The Tura Beach site is considered disturbed habitat. The wetland received water from the STP and was adjacent to a golf course. The golf course contained three dams and areas of emergent macrophytic plants (Spikerush). Although no *L. aurea* were located in the large permanent lagoons/dams, animals could use habitat within the Tura Beach STP and the Golf Course.

Table 1. Location and habitat assessment of historic and new sites for *L. aurea* in south-eastern NSW.

Note: easting prefix 2 = zone 56, prefix 7 = zone 55. AM = Australian Museum; D = distance from sea (km); A = altitude (AHD, in metres); SF = State Forest; NR = Nature Reserve.

Site	Easting	Northing	Date	Comment	D	A	Habitat Assessment
South Brooman SF	248300	6064450	no data	Littlejohn and Loftus	2.0	60	Not assessed during survey.
Nelligen Creek	239600	6051600	no data	Littlejohn and Loftus	0.2	5	Assessed in 1997. Near large ephemeral swamp.
Long Beach Rd	249700	6045700	1998	Farm dam M. Pennay record. Not detected in 2000 & 2001 (G. Daly, pers. obs.)	0.5	40	Farm dam with Spikerush. Adjacent resident remembers *L. aurea* were abundant.
Waldrons Swamp	239800	6027050	no data	No information	1.2	10	Sand mine with extensive areas of Cumbungi.
Longvale Swamp	240860	6029900	no data	No information	1.0	10	Extensive wetland with large areas of emergent macrophytes.
Moruya Heads	244300	6021600	1954	AM record, 14 specimens	0.1	5	Site either filled by shifting sand dunes or very ephemeral water body.
Pedros Swamp	242900	6019700	1963	AM, 2 specimens	0.5	5	Extensive undisturbed wetland with abundant macrophytic waterplants.
Moruya –Bodalla	238600	6012140	1953	AM, 6 specimens	0.5	5	Jebarrah Swamp and Trunketabella Swamp. *Gambusia* present.
Bobundara Swamp	239000	5973300	1990s	N. Hoye, pers. comm.	0.2	5	Extensive wetland with abundant macrophytic waterplants. *Gambusia* present.
Bermagui Lagoon	236700	5965600	1960s	D. Goodridge, pers. comm.	0.2	5	Coastal freshwater wetland with abundant areas of emergent macrophytes. Was partially saline.
Baracoot Lake	235500	5961500	1/9/78	J. Wombey	0.2	1	Not assessed during the current survey.
Murrah River a	234800	5954500	1980s	Mr John Gowing. Was abundant.	0.3	5	Numerous wetlands on floodplain. Macrophytic plants abundant.
Wapengo a	767000	5945100	1975	Mr John Hankinson. Was abundant.	0.5	5	Swampy creek. Cumbungi and Spikerush abundant.
Rutters farm	768100	5952500	1990s	Mr Dave Rudd. Was abundant.	0.3	5	Numerous wetlands on floodplain. Macrophytic plants abundant.
Farm dam near Murrah River	233760	5954032	1/11/80	R. Wells – 50 animals, reported in Lunney . and Barker (1986) plus Mr John Gowing	0.3	5	Numerous wetlands on floodplain. Macrophytic plants abundant.
Pambula	755600	5908600	1980s	10 - 20 adult frogs (P. Johnson pers. comm.)	0.2	1	Large coastal wetland. Macrophytic plants abundant.
Towamba Swamp	754000	5883300	1979	Numerous adults (J. Morris, pers. comm.)	4.5	10	Large freshwater wetland. *Gambusia* present. Historically was ephemeral.
Mumbulla State Forest	768500	5951600	15/9/94	Comp 2181; State Forest record: J. Roberts	3.0	10	Catchment of Murrah River; see above comments.
Pambula	756600	5906700	1922	AM record, 2 specimens	0.2	1	Large coastal wetland. Macrophytic plants abundant.
Nadgee Nature Reserve	763900	5851000	1974	AM record, 18 specimens	0.3	40	Coastal wetland in wilderness area.

Site	Easting	Northing	Date	Comment	D	A	Habitat Assessment
Digmans Creek	no data	no data	no data	AM record, 1 specimen			Not assessed during survey.
Reedy Creek crossing	766800	5985300	1968	AM record, 1 specimen	12.050		Not assessed during survey.
Merimbula	-	-	1993	Ehmann (1997) refers to P. Johnsons's captive colony			*L. aurea* abundant in tanks.
Nadgee	762400	5849200	1973	AM, 2 specimens	0.3	40	See above comments.
Saltwater Creek	766390	5882254	30/11/98	A. White	0.1	1	Coastal saline lagoon with adjacent sedgelands.
Whittakers Ck	233170	5993450	9/5/74	J. Waterhouse	5.0	130	Not assessed during survey.
near hut Nadgee NR	759500	5853500	1/10/74	D. Vleck	1.0	10	Creek with adjacent Sawsedge/Paperbark swamp.
Nadgee NR	760700	5870200	3/11/82	A. Mendis			See above comments.
Ludwigs Swamp Nadgee SF	749200	5870000	30/12/80	G. Webb	13.040		Large wetland with extensive Sawsedge.
Nadgee Moor Nadgee NR	762500	5850500	30/12/82	AM record	0.5	20	Extensive coastal heathland/sedgeland.
Nadgee NR	762500	5846500	23/11/82	A. Mendis			See above comments.
Nadgee Lake in NR	761600	5849700	1/12/74	AM record	0.2	0	Semisaline lake with adjacent heath/sedgelands.
Tura Beach	761100	5915700	15/12/00	Current survey – two adult frogs	0.5	0.4	Constructed wetlands near Sewerage Plant.
Nadgee NR			24/9/02	L. Evans, J. Baker and J. Blay. Exact location restricted information. Fifty plus calling frogs.	0.1	0.5	Flooded *Melaleuca ericifolia* wetlands.
Mumbulla State Forest	767750	5951200	26/2/96	Comp 2179; P. McGrath	3.0	10	Catchment of Murrah River; see above comments.
Quarantine Bay	755800	5892600	late 1980s	60 - 100 adult frogs seen regularly (P. Johnson, pers. comm.)	0.1	1	Sedgeland/ephemeral swamp adjacent to coastal lagoon.

Table 2. Sites where exotic species of fish were detected during survey

The frog species diversity is taken from nocturnal surveys. * indicated historic *L. aurea* site.

Site Name	Easting	Northing	Comment	Frog Species Diversity
Towamba Swamp *	753800	5883300	*Gambusia* present.	7
Bega STP	755600	5936500	*Gambusia* present	diurnal survey
Long Swamp	236700	5967200	Carp present.	6
Borang Creek	235450	6001500	*Gambusia* present.	0
Mimosa Rocks NP	767800	5939000	*Gambusia* present.	diurnal survey
Sunnyside: Victoria Ck	241000	5978700	*Gambusia* present.	5
Bobundara Swamp *	239000	5973300	*Gambusia* present.	4
Trunketabella Swamp	234400	6005400	*Gambusia* present.	1
Greenway Swamp	234200	6003700	*Gambusia* present.	3
Potato Point	241500	6001300	*Gambusia* present in dam	4
Jebarrah Swamp	241500	6002300	*Gambusia* present.	1
Williga or Y Swamp	242200	6024300	*Gambusia* present.	3
Waldrons Swamp *	242300	6027300	*Gambusia* present.	diurnal survey
Malua Bay	249300	6035500	*Gambusia* present.	2
Boydtown Creek	756100	5889500	*Gambusia* present.	2
Waldrons Swamp	239800	6027100	*Gambusia* present.	diurnal survey
Coila Lake	241900	6006400	*Gambusia* present.	4

Other frog species

Sixteen species of frog were detected during the diurnal and nocturnal surveys. On a presence basis the most commonly encountered species were Peron's Tree Frog *Litoria peronii* (77% of nocturnal sites), Common Eastern Froglet *Crinia signifera* (57% of nocturnal sites), Striped Marsh Frog *Limnodynastes peroni* (54% of nocturnal sites), Verreaux's Tree Frog *Litoria verreauxii* (38% of nocturnal sites), Ewing's Tree Frog *Litoria ewingi* (36% of nocturnal sites) and Tylers Toadlet *Uperoleia tyleri* (20% of nocturnal sites). In addition opportunistic searches detected Littlejohn's Tree Frog *L. littlejohni*, Blue Mountains Tree Frog *L. citropa*, Bleating Tree Frog *L. dentata*, Dwarf Tree Frog *L. fallax*, Lesueur's Tree Frog *L. lesueuri*, Eastern Pobblebonk *Limnodynastes dumerilii*, Spotted Grass Frog *L. tasmaniensis*, Haswell's Frog *Paracrinia haswelli*, Bibron's Toadlet *Pseudophryne bibronii* and *Geocrinia victoriana*.

The species diversity at sites ranged from 0-7 (Appendix). The abundance of frogs varied with respect to size of wetland and the prevailing weather conditions. Generally, larger wetland contained more frogs. However, environmental conditions also influenced the number and type of frog detected. The occurrence of rain during the last survey period in 2001 promoted breeding activity and *L. dentata* and *Limnodynastes peroni* were common to abundant during that period.

Four extensions to known ranges were made: *L. littlejohni* tadpoles in Nadgee Nature Reserve south of Eden (an approximate 20 km eastern range extension from Daly *et al.* 2002), *L. fallax* at Tura Beach and Batemans Bay (presumed translocated populations, approximately 250 km south of what is herein considered their natural occurrence). *Limnodynastes tasmaniensis* was also detected at several sites on the coastal plain between the Moruya and Coila Rivers (previously known in southern NSW from west of the Great Dividing Range). The occurrences of *Limnodynastes tasmaniensis* on this portion of the coast may also be a result of animals being translocated.

Post Survey records

Litoria aurea were detected at Nadgee Nature Reserve on 24 and 25 September 2002 (L.

Evans, pers. comm.). Approximately 50 frogs were heard calling during the day from one site on 24 September. On 25 September 2002 this number was again heard calling and another population of approximately 50 calling males some 800 metres from the original group. The frogs were calling from flooded Swamp Paperbark *Melaleuca ericifolia* wetland. The flooding was caused by the river being closed to the sea and water banking into the adjacent low-lying wetlands. On 15 October 2002 the sites were resurveyed and the river had broken through the sand bar to the sea. Subsequently the water level in the wetlands had lowered and no *L. aurea* were heard calling.

DISCUSSION

Changes in distribution and abundance of *Litoria aurea*

Collections in museums, previous survey results and anecdotal observations indicate that historically *Litoria aurea* were common up until the late1970's at a range of sites along the coast of NSW. *Litoria aurea* has subsequently declined or disappeared from many areas of the far south coast of NSW. The absence of *L. aurea* at most of these sites supports the hypothesis that there has been a substantial decline of the species on the far southern NSW coast.

Although *L. aurea* has been recorded in a wide variety of man made habitats such as bathtubs, cattle water troughs, dams and sewerage treatment ponds (Daly & Senior, 2000; Pyke & White, 2001), data indicate that the species' former stronghold on the south coast of NSW was large freshwater wetlands. The majority of sites surveyed (58%) in the current assessment were classified as having minimal human disturbance. This raises the question why has *L. aurea* disappeared from such a large area and from relatively undisturbed (*Gambusia* free) habitat?

Threatening processes

Threatening processes known to impact on *L. aurea* include predation of tadpoles by exotic species of fish, such as *Gambusia* and the fungal frog pathogen *Batrachochytrium* (frog chytrid). There is accumulating evidence, which indicates that the frog chytrid fungus is now widespread in a variety of habitats in eastern Australia (Berger *et al.*, 1999) and is a known pathogen of *L. aurea* (Wassens & Mullins, 2001). However, no sick *L. aurea* (or other species) were found during this survey. Chytridiomycosis is listed as a key threatening process under the Commonwealth EPBC Act (1999) and the TSC Act (1995).

Evidence indicates that the frog chytrid fungus may be more virulent at low temperatures (e.g., Retallick & Dwyer, 2000). This appears to manifest itself as a high incidence of declines and presumed extinctions of frogs at high altitudes. On this basis the prolonged winters in far southern Australia at higher latitudes (and altitudes) may also be a factor in the decline of *L. aurea* on the far south coast of NSW. However, there are two striking exceptions to this trend: the persistence of *L. aurea* in Gippsland Victoria (Gillespie, 1996) and the southern Tablelands of NSW (Wassens & Mullins, 2001).

Major declines in *L. aurea* populations have been recorded as occurring during the early 1980s (Osborne, 1986). If disease (amphibian chytrid) was the primary causal agent for the decline of *L. aurea*, then the evidence linking the disease with the decline was not recorded. Since amphibian chytrid is now widespread then why have the few populations in far southern NSW been spared?

Gambusia holbrooki was present at 16 sites indicating that the species has been introduced to numerous catchments on the far south coast. Laboratory experiments have shown that this fish is a voracious predator on the eggs and tadpoles of *L. aurea* (Morgan & Buttemer, 1996; Pyke & White, 2000). *Litoria aurea* was previously abundant at three of the sites where *Gambusia* was found (Waldrons Swamp, Towamba Swamp and Bobundara Swamp). The absence of *L. aurea* at these sites may be in part due to the presence of *G. holbrooki*.

Conservation measures

There is an urgent need to conduct additional surveys at Tura Beach and Nadgee NR for *L. aurea*. Since the Tura Beach population occurs near human habitation a management plan is required to minimise potential anthropogenic disturbances. There is also a need to conduct an education program via media releases and radio interviews so that the public is made aware of the species' historic and current status on the south coast of NSW.

An important component of the conservation of *L. aurea* is an accurate assessment of wild populations. Evidence from post survey assessments indicates that surveys for *L. aurea* need to be timed to coincide with localised flooding of potential breeding areas during the breeding season. In particular when coastal lakes/lagoons (or rivers) are intermittently closed to the sea and brackish water floods adjacent wetlands in spring. Unfortunately due to contractual agreements the current survey was primarily conducted during less than optimal weather conditions.

This survey has provided base line data for other temperate pond-breeding frogs and should be used as the basis for a strategic monitoring program to document trends in populations of declining and non-declining species.

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REFERENCES

Berger, L., Speare, R. & Hyatt, A. 1999. Chytrid fungi and amphibian declines: Overview, implications and future directions. Pp. 23-33 in, Campbell, A. (ed.) Declines and Disappearances of Australian Frogs. Natural Heritage Trust/Environment Australia, Canberra.

Daly, G. & Senior, C. 2000. Management plan for the population of Green and Golden Bell Frog at the Sussex Inlet wastewater treatment plant. Report prepared for Shoalhaven Water by Gaia Research Pty Ltd.

Ehmann, H. (ed). 1997. Threatened Frogs of New South Wales: Habitats, status and Conservation. Frog and tadpole study Group of NSW.

Gillespie, G.R. 1996. Distribution, habitat and conservation status of the Green and Golden Bell Frog *Litoria aurea* (Lesson 1829) (Anura: Hylidae) in Victoria. Australian Zoologist 30(2): 199-207.

Lunney, D. & Barker, J. 1986. Survey of the reptiles and amphibians of the coastal forests near Bega, New South Wales. Australian Zoologist 22: 1-9.

Morgan, L.A. & Buttemer, W.A. 1996. Predation by the non-native fish *Gambusia holbrooki* on small *Litoria aurea* and *L. dentata* tadpoles. Australian Zoologist 30(2): 143-149.

NSW NPWS Threatened Species Management 2000. Hygiene Protocol for the control of Diseases in Frogs. Information Circular No. 6. NSW National Parks & Wildlife Service, Sydney.

NSW NPWS (in prep.) Draft Recovery Plan for the Green and Golden Bell Frog (*Litoria aurea*).

Osborne, W.S. 1986. Frogs of the Canberra region. Bogong 7: 10-12.

Osborne, W.S., Littlejohn, M.J. & Thompson, S.A. 1996. Former distribution and apparent disappearance of the *Litoria aurea* complex from the Southern Tablelands of New South Wales and the Australian Capital Territory. Australian Zoologist 30(2): 190-99.

Pyke, G.H. & White, A.W. 2000. Factors influencing predation on eggs and tadpoles

of the endangered Green and Golden Bell Frog *Litoria aurea* by the introduced Plague Minnow *Gambusia holbrooki*. Australian Zoologist 31(3): 496-505.

Pyke, G.H. & White, A.W. 2001. A review of the Green and Golden Bell Frog *Litoria aurea*. Australian Zoologist 31(4): 563-598.

Retallick, R. & Dwyer, L. 2000. Using translocations to learn about frog declines. Conference abstract, Getting the Jump on Amphibian Diseases. James Cook University, Townsville.

Wassens, S. & Mullins, B.J.D. 2001. Rediscovery of a Green and Golden Bell Frog population in the southern tablelands. Herpetofauna 31(1): 58-63.

White, A.W. & Pyke, G.H. 1996. Distribution and conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales. Australian Zoologist 30(2): 177-189.

Appendix. Frogs detected during surveys for *Litoria aurea*

Litoria aurea = La, *Litoria citropa* = Lc, *Litoria dentata* = Ld, *Litoria ewingi* = Le, *Litoria fallax* = Lf, *Litoria jervisiensis* = Lj, *Litoria nudidigitus* = Ln, *Litoria peronii* = Lp, *Litoria verreauxii* = Lv, *Crinia signifera* = Cs, *Limnodynastes dumerilii* = Ld, *Limnodynastes peroni* = Li, *Limnodynastes tasmaniensis* = Lt, *Paracrinia haswelli* = Ph, *Pseudophryne bibronii* = Pb, *Uperoleia tyleri* = Ut

N/D indicates nocturnal or diurnal survey # Indicates historic/extant site of *L. aurea*. @ indicates sites where *Gambusia holbrooki* detected.

Repeated site names indicate separate survey sites as indicated by a, b, c, d, e, f, g.

STP = Sewerage Treatment Plant

Site No.	Site Name	N/D			La	Lc	Ld	Le	Lf	Lj	Ln	Lp	Lv	Cs	Ld	Li	Lt	Pb	Ph	Ut	Total Species
1	Towamba Swamp	N	#	@				*				*	*	*		*			*	*	7
2	Boydtown STP	N						*				*	*			*					4
3	Boydtown Creek	N		@								*	*								2
4	Boydtown Sandmine	N										*	*	*							3
5	Cocora Lagoon	N										*	*								2
6	Curalo Lagoon	N										*	*	*							3
7	Nadgee Lake	N	#									*		*							2
8	Nadgee sedgeland	D																			0
9	Bunyip Hole	D														*				*	2
10	North Nadgee lake	N	#									*				*			*	*	4
11	Black Head Swamp	D	#													*					1
12	Nadgee River flats	D																		*	1
13	Nadgee Hut	N	#			*					*										2
14	Bull Creek	N									*	*		*							3
15	Saltwater Creek	N	#																		0
16	Woodburn Creek	N																			0
17	Chip Mill header dam	N																			0
18	Chip Mill dam	N						*				*		*					*	*	5
19	Edron Lodge dam	N										*									1
20	Ludwigs Swamp	N	#								*	*	*	*		*			*	*	7
21	Green Cape	D												*							1

Site No.	Site Name	N/D		La	Lc	Ld	Le	Lf	Lj	Ln	Lp	Lv	Cs	Ld	Li	Lt	Pb	Ph	Ut	Total Species
22	Greenglade	D					*				*			*	*					4
23	Pambula STP	N									*		*							2
24	Pambula Swamp a	N	#				*				*				*					3
25	Pambula Swamp b	N	#				*				*				*					3
26	Pambula Swamp c	N	#								*	*			*					3
27	Pambula Beach	N	#								*	*			*					3
28	Tura Beach	N	#	*			*	*			*		*		*				*	7
29	Woodbine a	N					*				*		*						*	4
30	Woodbine b	N					*				*		*		*				*	5
31	Bournda NP dam	N					*				*				*					3
32	Scott Lagoon	N																		0
33	Lagoon	N									*									1
34	Bondi Lagoon	N											*							1
35	Bournda Lagoon	N																		0
36	Lagoon dam	N					*		*		*		*	*						5
37	Womboyne Golf Course	D																		0
38	Quarantine Bay	D	#																	0
39	Bermagui Refuse	D									*									1
40	Bermagui Golf Course	N					*				*	*								3
41	Bermagui Lagoon	N	#									*								1
42	Long Swamp	N					*				*	*	*		*				*	6
43	Wallaga Heights STP	N													*					1
44	Cuttagee Point	D																		0
45	Murrah River a	N	#								*	*								2
46	Murrah River b	N	#								*									1
47	Lotus Farm	N									*	*			*					3
48	Hergenans Rd a	N					*				*	*								3
49	Hergenans Rd b	N																		0
50	Hergenans Rd c	N									*	*								2
51	Hergenans Rd d	N									*	*								2
52	Hergenans Rd e	N									*	*								2

Site No.	Site Name	N/D			La	Lc	Ld	Le	Lf	Lj	Ln	Lp	Lv	Cs	Ld	Li	Lt	Pb	Ph	Ut	Total	Species
53	Hergenans Rd f	N										*									1	
54	Hergenans Rd g	D										*									1	
55	Bega STP	D		@																	0	
56	Tanja	N																			0	
57	Mimosa Rocks NP	N										*									1	
58	Wapengo a	N	#					*				*	*			*					4	
59	Mountain Rd	N										*	*			*					3	
60	Wapengo b	N										*	*			*					3	
61	Sandy Creek dam	N										*									1	
62	Mimosa Rocks NP	N										*		*							2	
63	Pedros Swamp	D	#												*						1	
64	Bithry's Inlet	N								*		*				*					3	
65	Rutters	N	#					*				*	*	*		*					5	
66	Ludo's	N						*				*	*								3	
67	Camel Rock	D																			0	
68	Sunnyside	N		@				*				*	*	*		*					5	
69	Tilba Lake	N						*				*	*	*		*					5	
70	Bobundara Swamp	N	#	@				*				*		*		*					4	
71	Merriwinga Swamp	N						*				*		*		*					4	
72	Fullers Beach	D												*							1	
73	Narooma Golf Course	N										*		*		*					3	
74	Bar Beach wetland	N						*				*		*		*				*	5	
75	Carters Beach	N						*						*		*					3	
76	Deusburys Beach	N										*		*							2	
77	Deusburys Point	N										*				*				*	3	
78	Yabbara Beach	N										*				*					2	
79	Brou Lake Refuse	D										*									1	
80	Borang Creek	D																			0	
81	Staffords Brickworks	D												*							1	
82	Mimosa Rocks NP	D												*							1	
83	Tathra STP	D																			0	

Site No.	Site Name	N/D			La	Lc	Ld	Le	Lf	Lj	Ln	Lp	Lv	Cs	Ld	Li	Lt	Pb	Ph	Ut	Total	Species
84	Wallagoot Lake	N										*									1	
85	Wallagoot Lake dam	N										*		*							2	
86	Kaluru dam	N												*		*					2	
87	Robin's dam	D					*	*				*		*			*			*	6	
88	Old Man Swamp	N						*		*		*		*		*					5	
89	Pedros Swamp	N	#							*		*		*		*				*	5	
90	Congo Sandmine	N																		*	1	
91	Williga or Y Swamp	N		@									*	*						*	3	
92	Speedway	N		@			*	*						*							3	
93	Malabar Creek	N					*					*		*		*					4	
94	Coathanger Quarry	N						*				*		*		*					4	
95	Blackfellows Point pond	N					*	*				*	*	*		*				*	7	
96	Jabarrah Swamp	N		@										*							1	
97	Potato Point a	N					*	*						*		*					4	
98	Potato Point b	N		@								*	*	*		*					4	
99	Horse Island a	N					*	*				*	*			*					5	
100	Horse Island b	N					*					*	*			*					4	
101	Greenway Swamp	N		@								*	*			*					3	
102	Greenway Farm	N					*					*	*			*					4	
103	Trunketabella	N		@								*									1	
104	Trunketabella Creek	N					*					*	*		*	*					5	
105	Coila Creek	N					*									*	*				3	
106	Horseshoe Farm	N						*				*	*			*					4	
107	Riverview Farm	N						*				*	*	*		*					5	
108	Old Mossy Point Rd	N											*	*				*		*	4	
109	Longvale Swamp	N										*	*	*		*				*	5	
110	Batemans Bay Golf Course a	N						*	*			*		*		*				*	6	
111	Batemans Bay Golf Course b	N						*				*	*	*							4	
112	Malua Bay	N		@										*		*					2	
113	McKenzie Creek	N										*		*							2	
114	Tomakin Swamp	N						*		*		*	*	*		*					6	

Site No.	Site Name	N/D	La	Lc	Ld	Le	Lf	Lj	Ln	Lp	Lv	Cs	Ld	Li	Lt	Pb	Ph	Ut	Total Species
115	Tomakin	N						*				*		*					3
116	Longbeach dam	D																	0
117	Depot Beach	D																	0
118	Waldrons Swamp	D									*								1
119	E. and W. Simes	N										*							1
120	E. and W. Simes (dam)	N				*				*		*							3
121	Coila Creek Road	N			*	*				*		*							4
122	Princes Highway	N										*		*					2
123	Bingi Fire Station	N			*	*						*			*				4
124	Cudbugga Creek	N				*						*		*					3
125	Bingi STP	N												*					1
126	Tuross Head Golf Course	N								*		*							
127	Ponds adjacent to above	N			*					*		*		*					4
128	Farm Dam Old Mill Rd	N				*				*		*		*				*	5
129	Farm Dam	D																	0
130	Bingi Beach swamp	D																	0
	Total		1	1	13	40	2	6	3	82	40	59	4	57	3	1	4	21	

Figure 1. Location of sites surveyed for *Litoria aurea*, south coast of NSW.
Closed triangles = nocturnal sites, *Litoria aurea* found; open triangles = nocturnal sites surveyed, no *L. aurea* found; large closed circles = diurnal sites surveyed (*L. aurea* not found); small closed circles = historical sites for *L. aurea*.

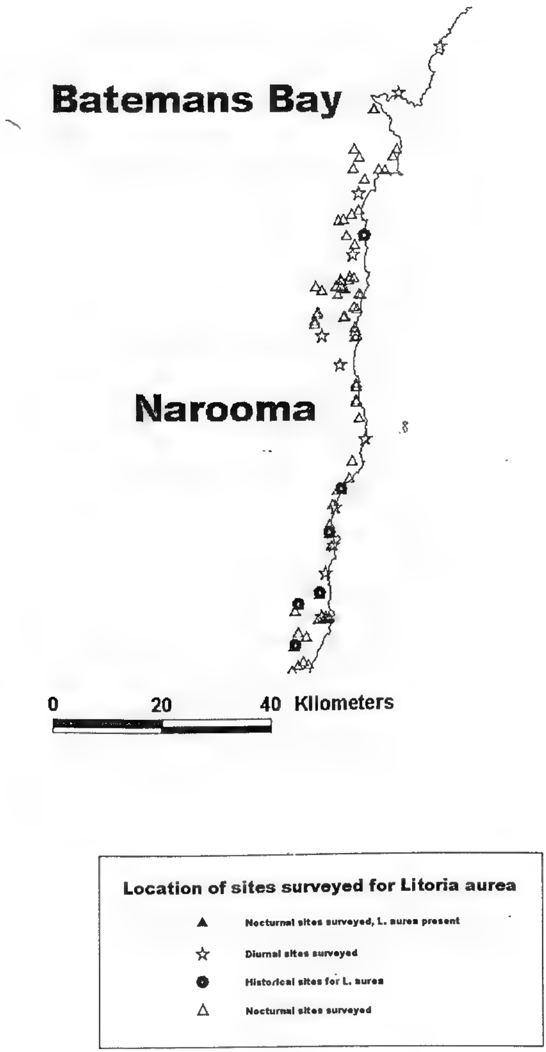
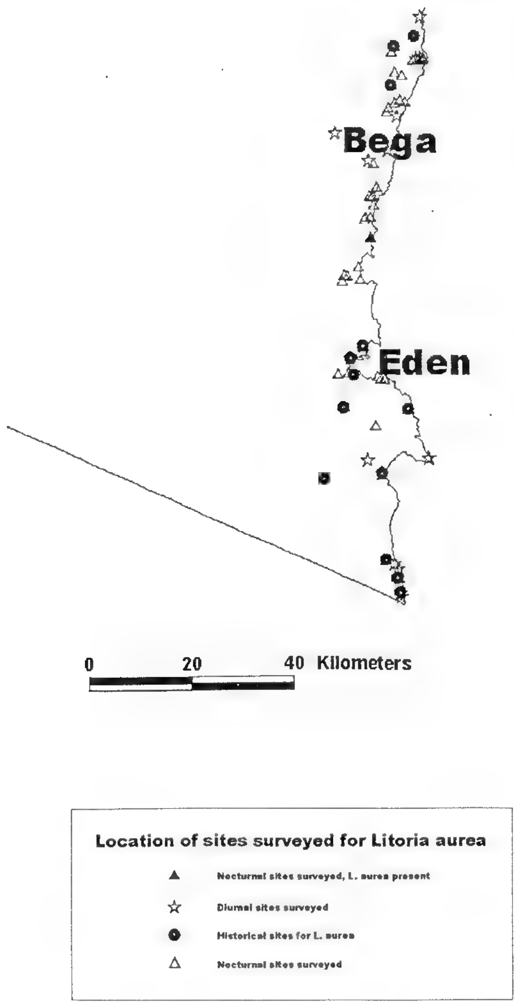


Figure 2. Location of sites surveyed for *Litoria aurea*, far south coast of NSW.

Closed triangles = nocturnal sites, *Litoria aurea* found; open triangles = nocturnal sites surveyed, no *L. aurea* found; large closed circles = diurnal sites surveyed (*L. aurea* not found); small closed circles = historical sites for *L. aurea*.



PREDATION BY THE LAUGHING KOOKABURRA ON EASTERN BLUE-TONGUED LIZARDS

David E. O'Connor
Biological Sciences A08,
University of Sydney, New South Wales, 2006.

INTRODUCTION

Eastern blue-tongued lizards, *Tiliqua scincoides*, are large skinks (total length 450-525 mm; Cogger, 2000) commonly found in Sydney suburban back yards (Koenig *et al.*, 2001a). Eastern blue-tongues thrive in such habitats, but life in the suburbs is not without risks and blue-tongues commonly fall prey to cars, dogs and cats (Koenig *et al.*, 2001b). Given their large size, eastern blue-tongues are generally assumed to be safe from avian predation once past a juvenile stage. Here I document two predation events by the laughing kookaburra, *Dacelo novaeguineae*, on relatively large eastern blue-tongues.

OBSERVATIONS

Location: Western Sydney suburbs.

Habitat: Small suburban backyard (8 m x 12 m) consisting of a mown lawn centre area with a 1 m border on all sides of either uncut grass or gardenias and then a 2 m fence.

Date and Time: Observation 1: 5 January 2003, 1400 hrs. Observation 2: 3 February 2003, 1745 hrs.

Weather: On both days the weather was warm (25 - 35°C) and sunny.

Notes: The details of the attacks were similar on both occasions. The lizards were in a small patch (1 m by 2 m) of tall (~ 20 cm) uncut grass adjacent to a corner of the yard. In both instances the kookaburra was perched on the fence 3 m away from the lizard at a height of 2 m. Laughing kookaburras are commonly observed in that location surveying the yard for prey items. The bird then dived into the grass, emerging from the grass with the lizard in its beak. In both cases, the lizard was moving and therefore still alive but neither were vigorously struggling. The birds then readjusted the position of the lizards in their beaks before flying off. Based on previous work on the black rock skink (*Egernia saxatilis*), I estimated both blue-tongues to have a total length of 30 cm. Unfortunately, mass-length data are unavailable for *T. scincoides*. However, a preserved specimen (R135353) in the Australian Museum with total length 30.9 cm had a mass of 125 g (body cavity opened and drained of fluid).

DISCUSSION

The laughing kookaburra is a large (adult size ca. 350 g, 45 cm) hole-nesting kingfisher endemic to eastern Australia (Legge & Cockburn, 2000; Simpson & Day, 1996). Unlike most other kingfishers, laughing kookaburras take mostly terrestrial prey, which they capture by perching above a foraging area and then diving on it (Simpson & Day, 1996, pers. obs.). Kookaburras are thought to prey on a number of reptiles, but the actual species taken is rarely reported. There are few records of kookaburras taking blue-tongue lizards. A 15 cm *Tiliqua nigrolutea* was found in the stomach of a Tasmanian kookaburra (Green *et al.*, 1988) and a "freshly killed" *Tiliqua rugosa* was observed in the beak of another kookaburra but no mention is made of its size (Sedgwick, 1940). Although not mentioned in the text, the cover of the book "Kookaburras" (Parry, 1970) shows a kookaburra with a *Tiliqua scincoides* in its beak. Given the relative size of the blue-tongue compared to the bird and its beak, this blue-tongue is also estimated to be about 15cm long.

What was surprising about the observations I report here was the size of the lizards involved

~ 30 cm total length. A lizard's vulnerability to avian predation is thought to be strongly influenced by its size (Blomberg & Shine, 2000), and although lizards of this size are anecdotally assumed to be safe from predation by non-raptors, my observations indicate that they are vulnerable to large non-raptors like the laughing kookaburra. Whilst other carnivorous non-raptors are as large or larger than laughing kookaburras (e.g., currawongs, ravens, crows; Higgins, 1999), these have never been reported to take large reptiles. It is presumably the power of the laughing kookaburras initial strike that allows it to subdue such prey (although it was unfortunate that both birds flew off before I was able to see whether they could actually consume the blue-tongues). Alternatively, the kookaburra's dislike of carrion and dead prey items (Higgins, 1999), may result in their tackling larger prey, with the accompanying risks, which these other species prefer to avoid.

ACKNOWLEDGMENTS

I would like to thank Glenn Shea and two anonymous referees for comments on the original manuscript.

REFERENCES

Blomberg, S.P. & Shine, R. 2000. Size-based predation by kookaburras (*Dacelo novaeguineae*) on lizards (*Eulamprus tympanum*: Scincidae): what determines prey vulnerability? Behavioral Ecology and Sociobiology 48: 484-489.

Cogger, H.G. 2000. Reptiles and Amphibians of Australia. 6th Edition. Reed New Holland, Frenchs Forest, NSW.

Green, R., Scarborough, T. & McQuillan, P. 1988. Food and feeding of the laughing kookaburra and tawny frogmouth in Tasmania. Tasmanian Naturalist 93: 5-8.

Higgins, P. (ed.) 1999. The Handbook of Australian, New Zealand and Antarctic Birds, Vol. 4, Parrots to Dollarbirds. Oxford University Press, Melbourne.

Koenig, J., Shine, R. & Shea, G.M. 2001a. The dangers of life in the city: patterns of activity, injury and mortality in suburban lizards (*Tiliqua scincoides*). Journal of Herpetology 36: 62-68.

Koenig, J., Shine, R. & Shea, G.M. 2001b. The ecology of an Australian reptile icon: how do blue-tongued lizards (*Tiliqua scincoides*) survive in suburbia? Wildlife Research 28: 215-227.

Legge, S. & Cockburn, A. 2000. Social and mating system of cooperatively breeding laughing kookaburras (*Dacelo novaeguineae*). Behavioral Ecology and Sociobiology 47: 220-229.

Parry, V. 1970. Kookaburras. Lansdowne Press, Melbourne.

Sedgwick, E. 1940. Birds of the Rockingham District. Emu 38: 82.

Simpson, K. & Day, T. 1996. Field guide to the birds of Australia. 5th Edition. Penguin Books Australia, Ringwood.

CAPTIVE BREEDING OF THE LEMON THROATED MONITOR *VARANUS BARITJI*

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INTRODUCTION

The Northern Territory of Australia is one of the few remaining areas in the world where large tracts of land are essentially undeveloped. With the proposed introduction of large-scale agriculture and industry, it is possible that within the next decade the landscape will change dramatically. Currently, these areas are home to a diverse reptile fauna. An interesting Northern Territory endemic species of reptile that is confined to the rocky hills north of the Katherine river is the Lemon-throated Monitor (*Varanus baritji*) (see Vincent & Wilson, 1999). This small, placid monitor is the subject of this article, and we describe the first breeding of this monitor in captivity.

The Lemon-throated Monitor is a relatively recent addition to the known herpetofauna of Australia, described by King and Horner in 1987. Previously, it had been confused with the spiny tailed monitor (*Varanus acanthurus*) (Worrell, 1963; Cogger, 2000), a confusion that had also befallen the small Storr's Monitor (*V. storri*), and the comparatively drab coloured Northern Blunt-spined Monitor (*V. primordius*). Since the separation of both *V. storri* and *V. primordius* from the *V. acanthurus* complex, many people have come to view these two smaller monitors as exciting additions to captive herpetofauna (Vincent & Wilson, 1999), whereas *V. baritji* has been viewed by reptile keepers as just another variant of *V. acanthurus* rather than a species in its own right.

In general, the Lemon-throated Monitor is perhaps the most placid monitor we have ever handled, almost never willing to bite, even when wild caught. Although not having the

Figure 1. Wild-caught captive female *Varanus baritji* from near Adelaide River township (produced clutch 1).

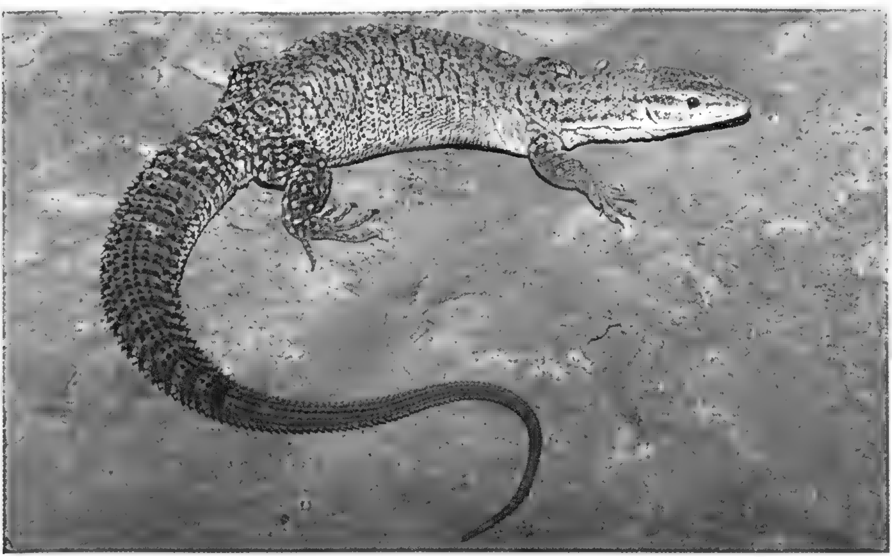
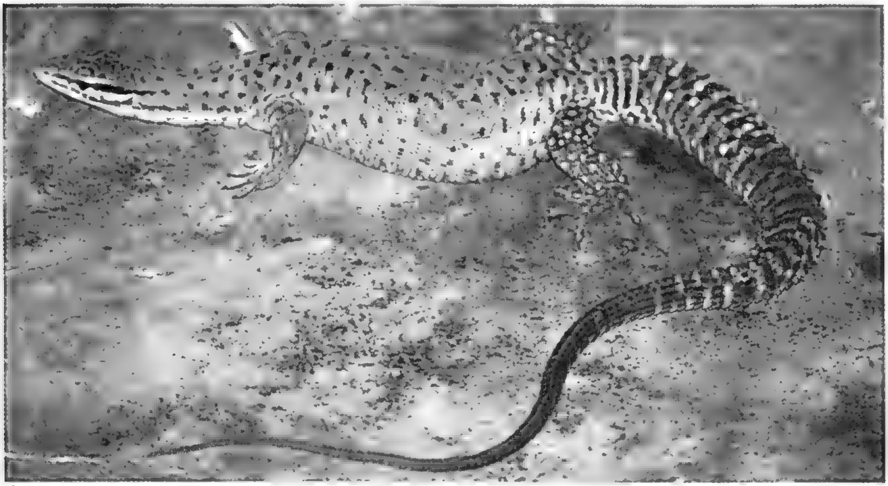


Figure 2. Female *Varanus baritji* from near Daly River turnoff on Stuart Highway.



bright red or yellow dorsal colours attributed to *V. acanthurus*, they can have a magnificent yellow throat and in some, a splendid bluish dorsal stripe. *Varanus baritji* is generally covered with black blotches, and occasionally also white scale flecks, on a fawn to dun coloured background (see Figs. 1-2) and only rarely have ocelli. They do not grow to the same length as *V. acanthurus* and are perhaps 10-20% smaller, without a thickset appearance. Hatchlings also have a tan background colour, but are covered with a number of large whitish spots. These spots become less prominent with age. *V. baritji* have a limited ability to climb, as they are for the most part a rock-dwelling species similar to *V. acanthurus*, burrowing in the soil beneath large rocks and boulders (Bedford & Christian, 1996).

Varanus baritji are found from Kakadu National Park, east of Darwin, to approximately the Daly River mouth to the west, so they do not have as large a range as *V. acanthurus*. They appear confined in distribution to the very top of the Northern Territory, an area north of the Katherine River. To date there are no known areas where *V. acanthurus* and *V. baritji* are sympatric, although they were thought to be so for some years (M. King, pers. comm.). However, within their known range there are different colour morphs which are still to be documented.

In general, *V. baritji* burrow under large immovable rocks set deep into the ground and are difficult to extricate. They appear to have additional burrows within their home range that they use during the wet season and that are not quite so well established. During the dry season (April to October) it can be very difficult to find active burrows, even though this is the breeding season. To date we have not established why this is so but hypothesise that reduced activity aids the conservation of energy during a period of the year that is very resource poor (little food or water available).

METHODS AND RESULTS

Six animals (two males and four females) were kept together in a large aviary (by GSB), while GH kept individuals separately, introducing males to females at weekly intervals. The behavioural observations reported below are from the aviary group. One of the males in this group was very large (200 mm SVL), the other small (120 mm SVL). The large male was the largest animal in the aviary; the smaller male was the second smallest animal, so there was a large size disparity. Despite the size difference there

was never any agonistic behaviour observed between the two animals, with the smaller animal unsuccessfully attempting to mate with the same female with which the large male had successfully mated.

In late June to early July the large male would head bob vigorously, possibly indicating that the female was in season, and his intent to mate with her. He would follow her around, bite her neck, and then attempt to mount her. The female spent some days resisting his advances. After the male had mated with the female many times, she was removed from the cage to determine whether other females were receptive of the male's advances. No further mating was observed with other female *V. baritji*. Although no agonistic behaviour was seen between males, upon removal of the receptive female, the large male spent considerable time attempting to mate with the smaller male. This may possibly be a dominant behaviour similar to the social structure observed in some pythons (Barker *et al.*, 1979; Bedford & Sullivan, 1993), although it may also be an aberrant behaviour induced by captivity. Even when the receptive female was returned to the cage, the large male divided his time attempting to mate with both animals. During 2000, no other female was observed to be receptive. Egg clutch 1 was laid 45 days after the last observed mating. Eggs were laid in moist desert sand in late afternoon. Although the eggs were buried in sand, the female blocked the entrance to the egg chamber with her body. The eggs were dug up soon after being buried. It would have been interesting to investigate whether the female's presence was a form of egg protection. However, she showed no sign of aggressive behaviour while the eggs were being removed.

Four clutches of *Varanus baritji* eggs were laid: in August (n = 2) and September 2000 and September 2001. One of the August clutches (clutch 2) and the September 2000 clutch were from the same female. The three measured clutches (all from 2000) consisted of five, eight and nine eggs, from which 15 hatchlings emerged. The mean egg dimensions were 31.6 x 16.2 mm (range 28.5 x 16.5 – 32.5 x 16 mm) with a mass of 4.8 g (range 4.1 – 5.0 g). Mean hatchling dimensions were 58.7 mm snout-vent length (SVL; range 52.0 – 62.0 mm), 85.2 mm tail length (TL; range 78.0 – 94.5 mm) and mass 3.5 g (range 3.1 – 4.2 g). Data are presented by clutch in Table 1. Clutch number one was laid 19.viii.2000 and hatched after 103 days at 32°C. Clutch two hatched after 110 days at approximately 32°C, while clutch three hatched after 104 days at the same temperature.

Table 1. Egg and hatchling morphometrics for captive bred *Varanus baritji*. Mean measurements are presented with standard deviations in parentheses.

Clutch # Date	No of eggs	Egg length	Egg width	Egg mass	No of hatchlings	SVL hatchling	TL hatchling	Mass hatchling
1 viii.2000	5	35.2 (0.9)	16.6 (0.8)	5.6 (0.5)	1	not measured	not measured	not measured
2 viii.2000	9	30.0 (1.0)	16.5 (0.4)	4.6 (0.2)	8	57.7 (3.3)	86.3 (4.8)	3.7 (0.5)
3 ix.2000	8	31.2 (1.2)	15.8 (0.3)	4.4 (0.2)	6	59.5 (1.9)	84.4 (3.3)	3.6 (0.1)

We have found the captive bred offspring to be easy to maintain and can double their mass within two months. To date they have fed on crickets, cockroaches, kangaroo mince with added vitamins and calcium, and gecko tails (*Hemidactylus frenatus*). As hatchlings grow, they have a tendency to target larger and larger food items, ignoring smaller prey that might otherwise be consumed. This possibly indicates a need to attain a large size quickly and enable them to be reproductive within one year. To date we have not maintained the off-

spring to adulthood but extrapolating from the observed growth rate would anticipate them attaining maturity within one year, similar to other small varanids.

Wild caught adult *V. baritji* were content to feed from the hand within a few months of capture and to date have presented no apparent keeping difficulties. They are an inquisitive animal and will investigate any new cage adornment, climbing all over a new rock or branch.

DISCUSSION

From the data presented here it appears that the Lemon-throated Monitor does have a seasonal breeding season, and like its larger relative, *V. acanthurus*, the mating season can be over an extended period during the year (Krebs, 1999). Whether they can be bred all year round like other small varanids has yet to be determined.

Although the sample is small, the incubation period of 100-110 days at 32°C is similar to that of *V. primordius* (Husband, 2001) and *V. acanthurus* (Bennett, 1998).

The smaller clutch consisted of slightly larger eggs, while the two larger clutches were consecutive from the same female, indicating that this species is capable of multiple clutches in a single year. Although not wishing to place too much emphasis on such a small data set, the second clutch was lighter in egg mass, but the offspring had a longer snout-vent length. The two clutches would have hatched about 6 weeks apart. Multiple clutches hatching at different times of the year may enhance the survival of the offspring, and enable them to take particular advantage of the biological rush of the wet season.

ACKNOWLEDGMENTS

All animals were collected under permits issued through the NT Parks and Wildlife Policy of sustainable use of wildlife (NT Government Policy Document 1994).

We would like to thank all the landholders who have supported our pursuit of animals under the system of sustainable use of wildlife, introduced by the NT Parks and Wildlife Commission.

REFERENCES

Barker, D.G., Murphy, J.B. & Smith, K.W. 1979. Social behaviour in a captive group of Indian pythons, *Python molurus* (Serpentes, Boidae) with formation of a linear social heirarchy. Copeia 1979: 466-71.

Bedford, G.S. & Sullivan, T. 1993. Observations of intra and interspecific aggression and possible mating heirarchy in the Northern Childrens python (*Liasis childreni*). Herpetofauna 23(2): 10-12.

Bedford, G.S. & Christian, K.A. 1996. Tail morphology related to habitat of varanid lizards and some other reptiles. Amphibia-Reptilia 17: 131-140.

Bennett, D. 1998. Monitor Lizards. Natural history, biology & husbandry. Edition Chimaira, Frankfurt am Main.

Cogger, H.G. 2000. Reptiles and Amphibians of Australia. Sixth Edn. Reed Books, Sydney.

Husband, G.A. 2001. Natural history and captive maintenance of the Northern Bluntspined Monitor *Varanus primordius*. Herpetofauna 31(2): 126-131.

King, M. & Horner, P. 1987. A new species of monitor (Platynota: Reptilia) from northern Australia and a note on the status of *Varanus acanthurus insulanicus* Mertens. The Beagle, Records of the Northern Territory Museum of Arts and Sciences 4(1): 73-79.

Krebs, U. 1999. Experimental variation of breeding season and incubation time in the spiny-tailed monitor (*Varanus acanthurus*). Pp 227-237 in, Horn, H.G. & Bohme, W. (eds). Mertensiella: Advances in Monitor Research 2. Deutsche Gesellschaft für Herpetologie und Terrarienkunde, Rheinbach.

Vincent, M. & Wilson, S. 1999. Australian Goannas. New Holland Publishers, Sydney.

Worrell, E. 1963. Reptiles of Australia, Angus and Robertson.

FREQUENCY OF SEA SNAKE STRANDINGS IN NORTH-EASTERN NEW SOUTH WALES

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Eleven sea snake species have been recorded in the waters of New South Wales (Cogger, 2000). The frequency of strandings of these species on the state's beaches has been poorly documented (Llewellyn *et al.*, 1994; Cogger, 2000). This note reports on the frequency of occurrence of sea snakes beachwashed on sections of the north coast of New South Wales over an approximate three-year period between 10 June 1997 and 15 September 2000.

Two stretches of coastline were patrolled on foot at varying intervals of between two and ten weeks:

1. Mooball Creek mouth (28°21'S 153°34'E) south to New Brighton (28°30'S 153°33'E), termed Pottsville Beach; total distance of 15 km.

2. Sandon River mouth (29°43'S 153°19'E) south to the Wooli River mouth (29°53'S 153°16'E), termed Minnie Water Beach; total distance of 36 km.

The distance covered on each survey varied, with a minimum of three kilometres traversed on any visit. On each survey the strandline, water's edge and storm tide zone areas of the beach were examined for beachcast specimens. Once located all specimens were identified using Cogger (1998), total length measured and individuals photographed for subsequent confirmation of species identification where required.

The incidence of strandings was low (0.02 individuals/km, all species combined), with only two species recorded (Table 1). The most frequently encountered species was *Pelamis platurus* (0.01 individuals/km, both stretches of coastline and all months combined), with individuals recorded in all but four months of the year (Table 1). The highest incidence rate was in September with 0.05 individuals/km detected. The majority of *P. platurus* encountered were alive (69%), with a mean total length of 78.3 ± 9.9 (SD) cm (range 64 - 92 cm). Three live and one dead individual had small numbers (<20) of goose barnacles (*Lepas*) attached to scales on the ventral surface.

This species was generally found beachwashed (n = 9) following periods of strong onshore winds, rough seas and when large numbers (>1000 individuals/km) of planktonic species, such as the Portuguese man-o-war *Physalia*, by-the-wind sailor *Velella*, ram's horn shell *Spirula* and the pelagic nudibranch *Glaucus* were washed ashore. *Pelamis platurus* has been described as a floating species that aggregates in driftlines and preys on small fish (McDowell, 1972; Heatwole, 1987). Therefore, the observed association between the stranding of this species and large numbers of zooplanktonic fauna is not surprising. However, even under conditions where large numbers of these zooplanktonic species were beachcast, *P. platurus* was only encountered on 28% of occasions in the three-year period.

All three individuals of *Hydrophis elegans* were recorded beachwashed on the Pottsville Beach in August 1998. Two specimens were found alive and the third appeared to have been killed after stranding. The total length of these individuals varied between 91 and 118 cm, with no goose barnacles attached. All individuals were washed ashore during calm conditions with low swells, light variable winds, and no zooplanktonic species such as *Physalia* or *Velella* beachwashed.

The incidence of strandings recorded was likely to be underestimated in the current study due to a combination of factors.

Frequent usage of beaches by members of the public may result in some stranded individuals being collected. Scavengers, particularly dingoes/feral dogs, goannas (*Varanus gouldii* and *V. varius*), Whistling Kite *Haliastur sphenurus*, Brahminy Kite *H. indus*, and the Torresian Crow *Corvus orru* may have further contributed to a reduced number of sea snakes encountered.

Pelamis platurus is regarded as a resident in pelagic waters off the New South Wales coast (Cogger, 2000). Ten additional sea snake species recorded in the region's waters are considered vagrants (Llewellyn *et al.*, 1994; Cogger, 2000). Factors such as global warming may influence the frequency of occurrence of these vagrant species. Examination of stranded individuals and monitoring stranding rates may assist with the identification of threatening processes and distributional change of this poorly known group of reptiles.

ACKNOWLEDGMENTS

Special thanks to Teresa Eyre for logistical support, Juno for keeping me company on the Pottsville Beach surveys, and Patrick Couper and Ross Sadlier for confirming identifications of *H. elegans* encountered. This study was partially funded by a grant from the Peter Rankin Trust Fund for Herpetology.

REFERENCES

Cogger, H.G. 1998. Reptiles and Amphibians of Australia. Reed, Sydney.

Cogger, H.G. 2000. The status of marine reptiles in New South Wales. Report to New South Wales Parks and Wildlife Service, Sydney. 65 pp.

Heatwole, H. 1987. Sea Snakes. New South Wales University Press, Sydney.

Llewellyn, L., Ellis, M., Martin, J. & Ferguson, A. 1994. Atlas of New South Wales Wildlife: marine mammals and reptiles. New South Wales National Parks and Wildlife Service, Sydney.

McDowell, S.B. 1972. The genera of sea snakes of the *Hydrophis* group (Serpentes: Elapidae). Transactions of Royal Society London 25: 189-247.

Table 1. Summary of sea snakes stranded on two stretches of coastline, north-eastern New South Wales between 1997 and 2000.

Month*	Distance (km)	*P. platurus*	*H. elegans*
January	99	-	-
February	64	-	-
March	96	1	-
April	94	1	-
May	109	1	-
June	73	1	-
July	94	2	-
August	70	-	3
September	89	4	-
October	66	-	-
November	89	1	-
December	62	2	-
Total:	1005	13	3

* Both stretches of coastline and all years combined.

HERPETOLOGICAL NOTES

A BICEPHALIC COASTAL QUEENSLAND CARPET SNAKE, *MORELIA SPILOTA MCDOWELLI* (SERPENTES: PYTHONIDAE)

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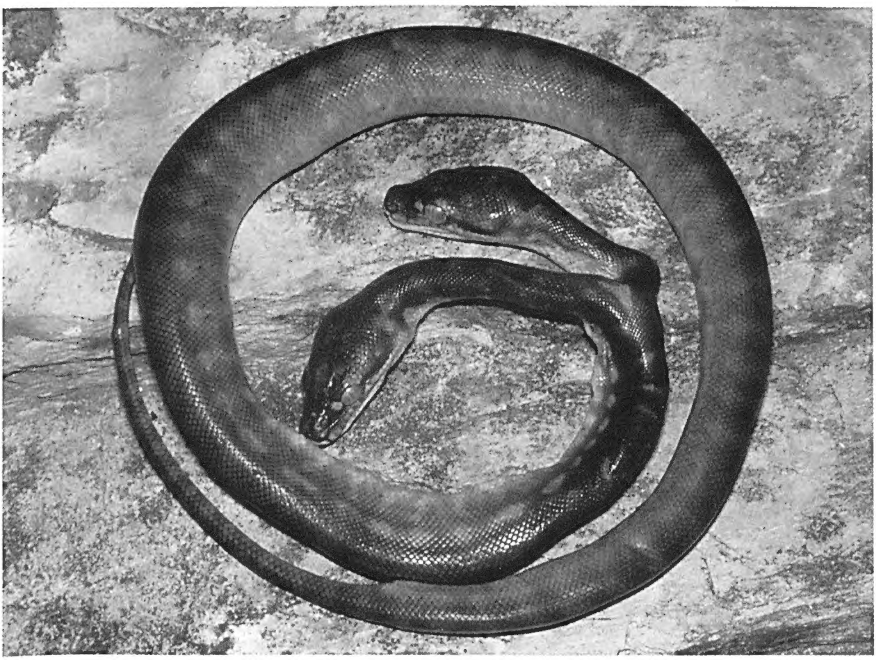
Recently, Maryan (2001) reported bicephalism in two elapids, an *Acanthophis wellsi* x *Acanthophis pyrrhus/Acanthophis wellsi* hybrid, and *Pseudonaja affinis*. This note reports a case in the python *Morelia spilota mcdowelli*.

A clutch of eggs hatched in 1996 from a mating between a pair of coastal Queensland carpet snakes in the collection of Victoria reptile breeder Dale Gibbons included a single bicephalic offspring, with head and anterior necks separated (Fig. 1). The other hatchlings were normal. Both heads of the bicephalic hatchling were active and flicked out their tongues and the snake externally appeared healthy. However, it died within a month of birth. The cause of death was not determined.

REFERENCE

Maryan, B. 2001. A note on a bicephalic Death Adder. Herpetofauna 31(1): 73.

Bicephalic hatchling carpet python, *Morelia spilota mcdowelli*.



BOOK REVIEW

UNDER THE MICROSCOPE: MICROSCOPE USE AND PATHOGEN IDENTIFICATION IN BIRDS AND REPTILES

Danny Brown, 2003.
53 pp., full colour photographs throughout.
Published by ABK Publications, PO Box 6288, South Tweed Heads, NSW 2486
(www.birdkeeper.com.au)
R.R.P. $22.95 + $4.35 postage. ISBN 0 9577024 8 5

This slim (just larger than A5) 53 page guide is a welcome addition to the growing range of Australian Bird Keeper (ABK) publications. Its aim is to provide basic training in microscope use and common (gastrointestinal) pathogen identification for aviculturists and herpetologists.

The text consists of an overview together with four main sections: The Microscope, Avian Pathogens, Reptile Pathogens and Artifacts/Pseudoparasites. The overview outlines the aim of the text, together with comments on the limitations of light microscopy (user and equipment) and an excellent summary of when to contact a veterinarian. Note that there is no information on the treatment of potential pathogens found via the use of a microscope - a veterinarian should be consulted to determine appropriate, if any, therapy.

The section dealing with the mechanics of the microscope and its use is well organised and written with details on such aspects as cleaning the microscope, using the various objectives correctly, preparing faecal samples and an overview of the interpretation of results.

The main bulk of the publication deals with identification of the various organisms that may be found in reptile or avian samples, dealing almost exclusively with faecal samples. These sections are well presented, detailing the various types of organisms likely to be encountered, with numerous full colour plates of sample faecal smears. The last section provides a similar format of items that may be mistaken as parasites - artefacts or pseudoparasites.

Overall, I found this to be a well structured and written guide that is an inexpensive addition to the herpetologist's library. The author is a veterinarian and a keen aviculturist and herpetologist, which is reflected in his clear, concise writing style. There is little to criticise in this publication. A future update could include identification of organisms from non-faecal sources, for example skin scrapings, and more detail on the life-cycles of parasites. Perhaps the subtitle should read "Microscope Use and Faecal Examination in Birds and Reptiles" to more accurately reflect the content. Recommended.

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NOTES TO CONTRIBUTORS

Herpetofauna publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

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Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

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Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – black and white prints or colour slides are acceptable.

Use a recent issue of Herpetofauna as a style guide.

A computer disc may be submitted instead of hard copy but this should not be done until after the manuscript has been reviewed and the referees' comments incorporated. Computer discs must be HD 1.44 mb 3.5" in Word for Windows; Wordperfect; Macintosh or ASCII. Any disc must also be accompanied by hard copy.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

REFERENCES

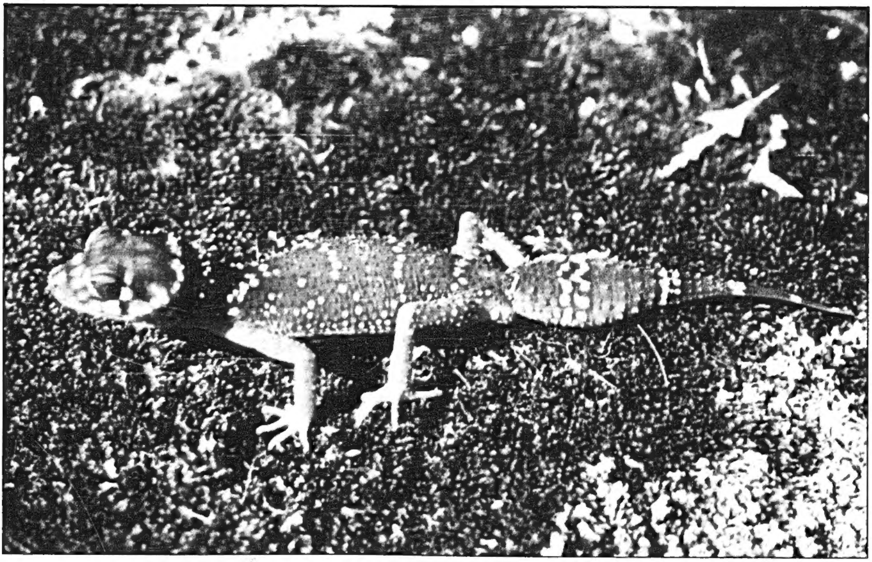
Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

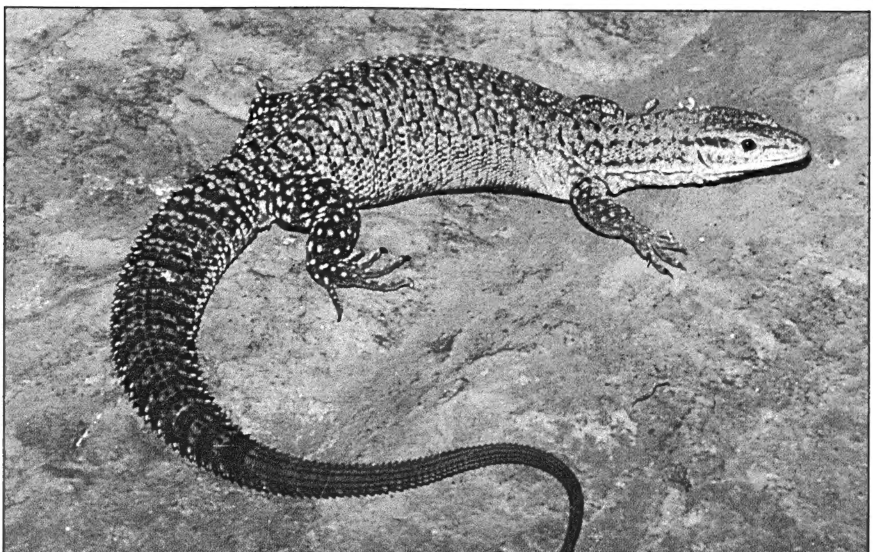
Significant changes will require the article to be revised and a fresh manuscript submitted.

REPRINTS

The senior author will receive 25 reprints of the article free of charge.



Thick-tailed gecko (*Underwoodisaurus milii*) from Mt Kiaora, NSW. See paper on page 59.
(Photo by C. Coombes).



Lemon-throated monitor (*Varanus baritji*) from near Adelaide River, NT.
See paper on page 105.